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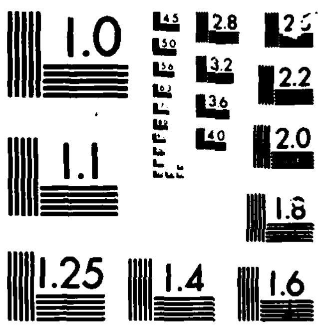

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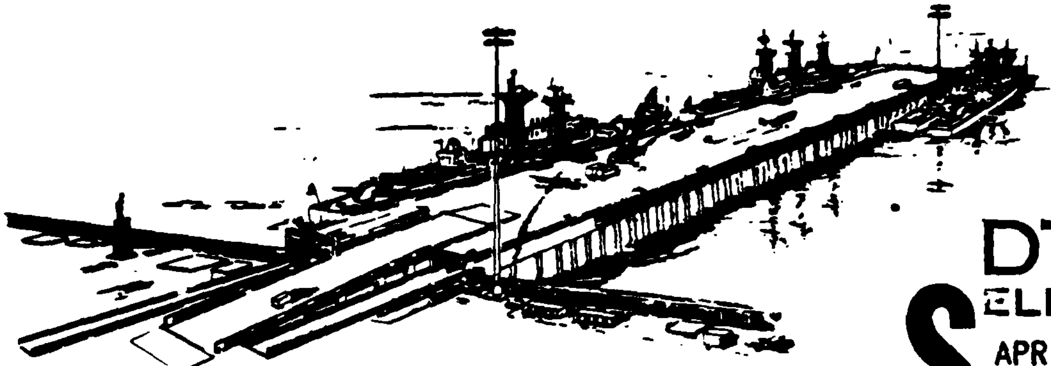

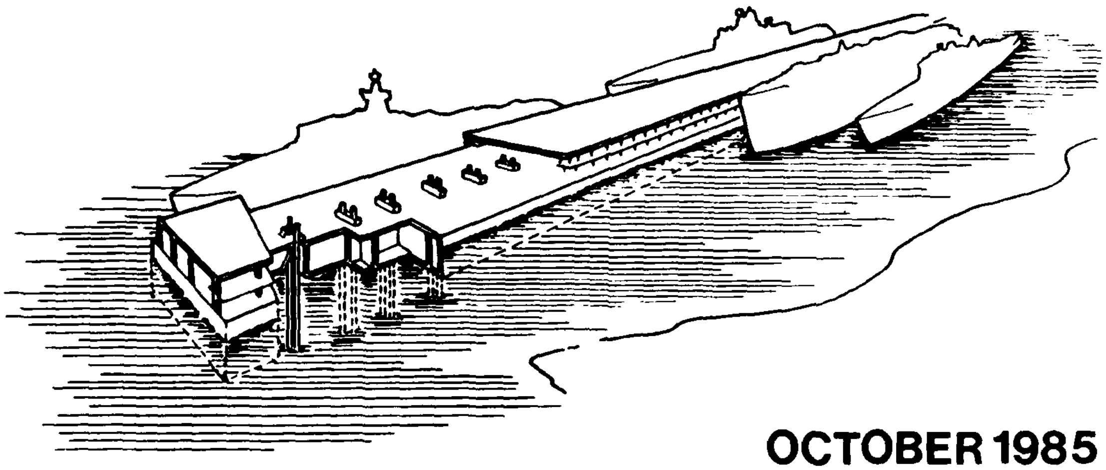

OCTOBER 1985

NAVAL CIVIL ENGINEERING LABORATORY

PREFACE

The Advanced Pier Concepts Users Guide consolidates several Naval Civil Engineering Laboratory (NCEL) documents and sponsored studies, and other related documents, into one presentation to be used by shore facilities planners and designers in preparing studies, projects, plans and specifications for Navy piers.

The Guide represents an assemblance of recommendations, guidance, and information covering work accomplished under prior NCEL tasks, SOUTHNAVFACENGCOM Pier Zulu design, as well as ongoing work currently being performed on pier systems. In addition, the Guide covers the overall results obtained from the two Naval Facilities Engineering Command (NAVFACENGCOM) sponsored Pier Designs Workshop/Conferences as well as future work required to resolve current inadequacies in the design of Navy piers.

The basic Guide is subdivided into 11 sections including:

- <u>Introduction</u> - outlines the status of new design concepts including the fixed, double-deck pier and the floating pier.
- <u>Pier configuration</u> - covers planning factors pertaining to deck elevation, berth length and width, deck area, and critical clearances for single- and double-deck piers.
- <u>Design live load requirements</u> - describes observations on existing piers and estimates for floating piers.
- <u>Structural design</u> - characterizes a double-deck, pile-supported pier, and a floating pier.
- <u>Fendering systems</u> - covers the latest designs for resilient fenders.

- Utilities - covers the design of utilities galleries, utilities requirements and offsets, power conditioning and cable handling equipment, and the steam purity program.
- Pier lighting - includes requirements, alternatives, and recommended design.
- Deck fittings - specifies considerations required for double-deck pier design.
- Access facilities - specifies considerations covering brow, platform, and conveyor usage in conjunction with new pier designs.
- Pier design evaluation - analyzes system for performing life cycle cost (LCC) analysis, benefit analysis, and benefit to cost analysis of various pier designs.
- NCEL Port System Project - includes Research, Development, Test, and Evaluation (RDT&E) direction resulting from Pier Design Concepts Conference input.

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SECTION 1

INTRODUCTION

The Advanced Pier Concepts Users Guide consolidates several Naval Civil Engineering Laboratory (NCEL) documents and sponsored studies, and other related documents, into one presentation to be used by shore facilities planners and designers in preparing studies, projects, plans and specifications for Navy piers.

The Guide provides material on a wide range of subjects including:

- New concepts for pier configuration including double-deck piers, floating piers, and utility galleries.
- Recommendations covering the methodology for determining the optimum pier width and main deck elevation,
- Special structural considerations associated with double-deck, pile-supported and floating piers,
- Information on ship characteristics and berthing requirements including utilities capacities and proposed service locations.
- Innovative designs covering both electrical and mechanical services to ships,
- Information and recommendations on resilient fender systems.
- A new pier lighting concept,
- Information on deck fittings and access facilities,
- A methodology for performing a pier design evaluation.

The contents are a compilation of work accomplished under prior NCEL tasks as well as ongoing work being performed on pier systems. In addition, the Guide covers the overall results obtained from two Pier Designs Workshop/Conferences as well as future work required to resolve current inadequacies in the design of Navy piers.

1.1 Background

The average age of Navy piers which are used for active berthing is about 35 years. Service life specified as the basis for design in Design Manual DM-25 is 25 years. Actual service life expectancy is 50 years. Meanwhile, the average age of the Navy's active ship inventory is only 15 years, and is decreasing.

As a result of this disparity in age and service life, the requirements of the ships (form, draft, displacement to be accommodated, weapon systems, and utility requirements, for example) change far more rapidly than does the design of the piers to accommodate them. The pier designs, which are predicated on requirements prevailing at the time the projects are conceived plus foreseeable projection of trends, tend to lag the changes in ship design. Consequently (and excepting certain dedicated support facilities, such as those for the TRIDENT), with the passage of time, the supporting shore facilities tend to mismatch the requirements of the ships and to lack the desired support capabilities.

As a part of the overall Port System Project, NCEL is accomplishing a major Pier Design Project with the goal of improving designs of Navy piers. The charter for the project, as stated in a Navy Decision Coordinating Paper, is to "acquire...piers which are cost effective and responsive to changing user requirements (new ship types)." One of the first steps was the NAVFACENGCOM/NCEL Pier Design Workshop held in February 1981. This Workshop established the following guidance:

- New pier designs should be dictated by operational and logistic support requirements. Multilevel piers should be given full consideration and judged on a life-cycle cost basis rather than simple comparisons of initial cost.

- Clear pier decks should be a paramount goal in new designs.
- Initial concept designs should be made for CG/DD/DDG/FF/FFG/AD type ships.
- Naval Station (NAVSTA) Charleston, Military Construction (MILCON) Project P-135 as the initial testbed for new concepts should be utilized.

In addition, comprehensive input was provided by Commander in Chief, Atlantic Fleet (CINCLANTFLT), Commander in Chief, Pacific Fleet (CINCPACFLT), and NAVFACENGCOM concerning current pier deficiencies, berthing support problem areas, and ideas for improving designs.

Since the 1981 workshop, the following major items have been accomplished or are underway:

- A Ship Data and Berthing Requirements Guide was developed containing ship physical data, pier utilities requirements, and other information on berthing requirements for the AD-41, CG-47, DD-963, DDG-51, FF-1052, and FFG-7 classes. This document gathers information from various sources into a reference for planners and designers.
- Two parallel conceptual design efforts were accomplished by Architect and Engineer (A&E) firms to obtain ideas for improving piers in the near term. One proposed a fairly conventional pile-supported pier with walk-through utility galleries and a unique fender design. The other firm proposed a floating pier, which is indeed unique.
- Further development work was accomplished including dynamic behavior analyses, shore-to-pier ramps and utility connections designs, life-cycle cost, and construction of a scale model due

to certain significant advantages of a floating pier; e.g., constant elevation relative to ships, adaptable to sites not suited for pile-supported pier, natural two-deck configuration, offsite construction, and relocatability.

- The utility gallery concept was further developed, by a separate design effort, for both fixed and floating pier designs.
- A methodology for determining the optimum pier deck elevation for surface combatant ships was developed. It shows a main deck elevation of 19-21 feet (ft) above the waterline to be optimum.
- A pier design evaluation system was developed to rate the efficiency and operational performance of alternative designs.
- A pier utilization study and analyses of day-to-day functions and Phased Maintenance Activities was completed using NAVSTA, San Diego and NAVSTA, Norfolk as testbeds. This study obtained onsite data for 58 arrivals/departures, crane service, cargo loadings, and a number of other pier operations. Labor, equipment, and time were recorded and analyzed to help determine how pier designs can be improved to make pier functions more efficient and less labor intensive.
- The Southern Division, NAVFACENGCOM, completed final design and commenced construction of Pier Zulu, NAVSTA, Charleston which reflects the first application of some of the new concepts. This pier will have two decks with utility functions on the lower level. The main deck is 20 feet above mean low water; 7 feet higher than the average pier today.

In February 1984, a Pier Design Conference was held in order to evaluate the direction and progress of the pier design studies conducted from 1981 to 1984. Specific objectives of the conference included:

- Review of the current pier MILCON projects at Treasure Island, Charleston, and Staten Island.
- Evaluation of new design concepts for surface combatants developed to date, recommending new or changed project direction, and recommending priorities of work for the project.
- Development of strategy and action items for the implementation of improved pier design concepts.

Representatives of CINCLANTFLT, CINCPACFLT/Commander, Naval Surface Forces, Pacific (COMNAVSURFPAC), NAVSTA Mayport/Norfolk/Charleston/San Diego/ Treasure Island, Naval Ship Weapon Systems Engineering Station (NSWSES), NAVFACENGCOM Headquarters, NAVFAC Engineering Field Divisions and Public Works Centers attended. The conference generally endorsed the work accomplished in the Pier Design Project with two major additions/changes in direction. These changes included the addition of amphibious and services ships to the berthing requirements for a surface combatant pier, and the need to improve typical existing piers. Excellent input and recommendations were provided on a number of pier design and berthing support aspects. Specific conclusions and recommendations resulting from the conference are contained in section 11.

1.2 Scope

1.2.1 Application. The Guide is directed at outlining planning and design concepts for piers supporting small and medium surface combatants. The design concepts are based on the following classes of ships:

CG-47
DD-963
DDG-51
FF-1052
FFG-7

In addition, the Guide provides certain planning factors for the AD-41 class destroyer tender.

While the Guide specifically addresses small and medium surface combatants, many of the concepts are general in nature and are applicable to many other classes of ships.

1.2.2 References. The material covered in the Guide is extracted from the following documents:

- NCEL CR 82.031, Conceptual Design of Navy Floating Pier, T.Y. Lin International, September 1982
- NCEL CR 83.007, Innovative Design Concepts - Piers for Surface Combatants, Sidney M. Johnson and Assoc., January 1983
- NCEL CR 83.032, Conceptual Designs for Berthing Pier Galleries and Deck Lighting, Brown & Root Development, Inc., June 1983
- NCEL Technical Note, TN no. N-1586, Steam Separator T&E, August 1980
- NCEL Technical Memorandum, TM no. M-62-82-03, The Suitability of an Automatic Voltage Regulator to Solve Shore-to-Ship Power Regulations Problems, May 1982
- NCEL Technical Note TN no. 1689, Port Systems Project: Shore-to-Ship Electrical Power Cable Handling Equipment, March 1984
- User Data Package, Shore-to-Ship Electrical Power Cable Handling Equipment, April 1984
- NCEL Technical Memorandum, TM no. 55-83-08, Naval Pier Resilient Fender Systems Study, May 1983
- Proceedings of a Workshop Held at the Civil Engineering Laboratory (CEL) 24-26 February 1981
- Gee & Jenson, Concept Study for Berthing Pier (MILCON Project P-135) Naval Station, S.C., September 1982

- T.Y. Lin, Supplemental Report to Conceptual Design of Navy Floating Pier, January 1983
- VSE Report, Ship Data and Berthing Requirements for Small and Medium Surface Combatants, March 1983
- VSE Report, Pier Utilization Study for Small and Medium Surface Combatants, September 1983
- Gee & Jenson, Plans and Specifications, Berthing Pier (MILCON Project P-135), Naval Station, S.C., 7 November 1983
- VSE Report, Pier Design Evaluation System, December 1983
- Brown & Root Development Inc. Report, Floating Pier Concept, Preliminary Engineering Studies and Preliminary Construction and Life Cycle Cost Estimate at Pier 92, Port of Seattle, Washington, December 1983
- VSE Report, Life Cycle Cost Comparison of Navy Floating Pier and Fixed Pile-Supported Pier, January 1984
- Pier Design Conference Proceedings, February-March 1984
- VSE Report, Steam Purity Measurement System Feasibility Report, April 1984
- VSE Report, Navy Pier Lighting Investigation, March 1985

1.2.3 Features. The contents of the Guide cover:

- Planning factors pertaining to deck elevations, berth length and width, deck area, and critical clearances for normal pier operations and phased maintenance activities.
- Design loads covering recorded lifts on current piers, and naval architectural considerations required for design of a floating pier.
- Structural design characteristics of a double-deck, pile-supported pier, and a floating pier.
- Design of resilient fender systems.

- Utilities support services including design of utilities covering requirements and offsets, gallery design, service outlets, power conditioning equipment, cable handling equipment, and steam purity programs.
- Pier lighting design including requirements, alternatives and a recommended design.
- Deck fitting recommendations.
- Potential improvements in the use of brows and platforms for personnel access and in the use of mobile or portable conveyers for transfer of ship's stores.
- A pier design evaluation system including utility benefit analysis and life-cycle cost approach.
- A summary of the recommendations resulting from the February-March 1984 Pier Design Concepts Conference, and future RDT&E requirements.

1.3 New Design Concepts

Two new innovative pier design concepts are introduced in the Guide aimed at improving pier-to-ship support. They are:

- The double-deck, pile-supported pier
- The floating pier

1.3.1 Double-Deck Pier. A double-deck, pile-supported pier, as shown in figure 1-1, is estimated to have qualities far superior to a wider, single deck pier. With a pier-to-ship interface almost twice the single deck pier, operations can be conducted much closer to the edge of the pier and the ship.

Utilities, which in the past have always occupied the prime pier area adjacent to the ship, are now located on the lower deck, protected and provided

with quick access and ample storage space. The net impact is to fulfill the realization of a "clear" main deck.

Access to all utilities systems, including transformer vaults, is available from the lower deck. This eliminates congestion on the main deck while facilitating maintenance and repairs to the different utilities. The time to connect and disconnect utilities services are also substantially improved.

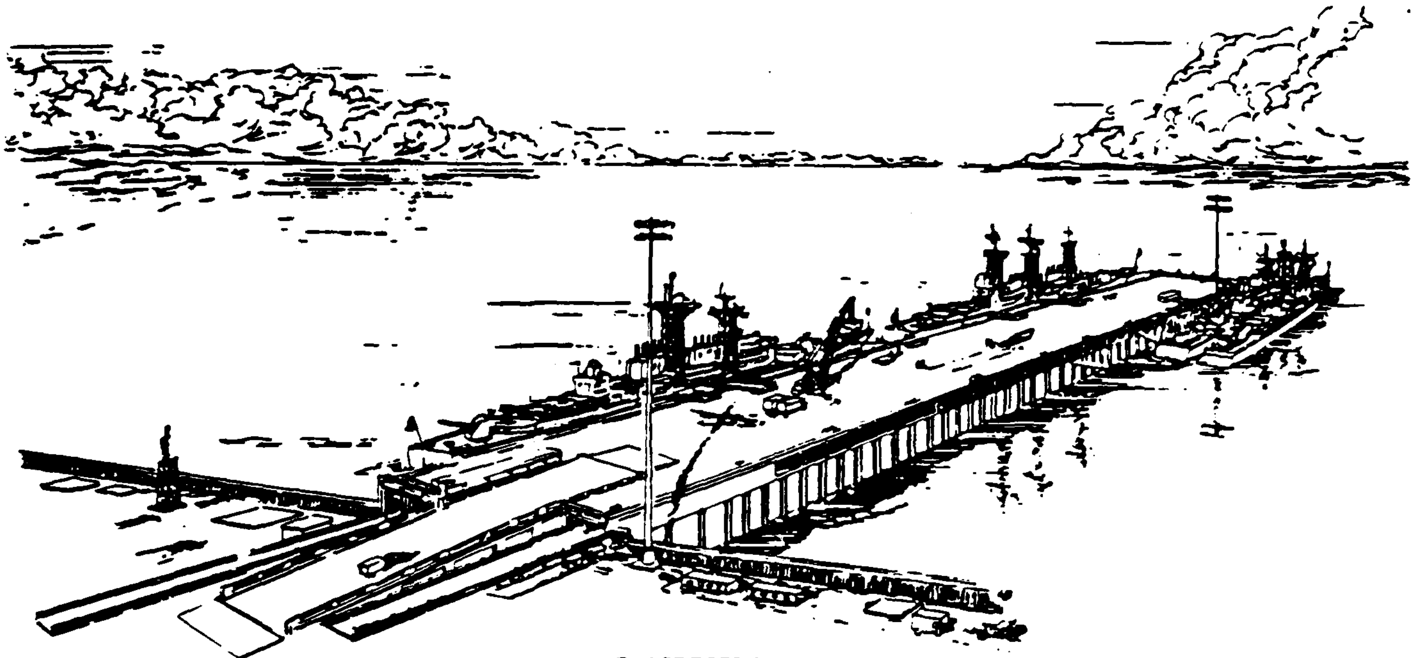
Crane access to the ship is substantially closer with the absence of the utilities hoses and cables, thereby permitting more efficient utilization of smaller cranes (figure 2-1).

Vehicular access as well as limited storage is also available on the lower level.

More advanced fender systems are employed.

1.3.2 Floating Pier. A floating pier having two decks, as shown in figure 1-2, was conceived as the appropriate structure to serve combatant ships in a manner that is in many ways superior to that of fixed piers. The pontoon segment of the pier was sized at 75 feet wide by 18 feet deep in cross-section and fabricated of prestressed concrete. NAVSTA Charleston was chosen as the planned site in order to provide environmental and operational parameters for design.

Double-wall construction in the unlikely event of collision damage, and three buoyancy cells across the section were provided for damage stability. Longitudinally, bulkhead walls were located every 40 feet. The overall length of the pier structure was 1200 feet with a 50-foot gap between the pier and shore, which is spanned by ramps. The pier is designed to be constructed as two 600-foot long units. This length permitted offsite construction and subsequent tow to the final site. The two units would be joined rigidly by post-tensioning techniques and installed onsite by driving vertical piles through wet wells located down the centerline of the pier. The piles anchor the pier



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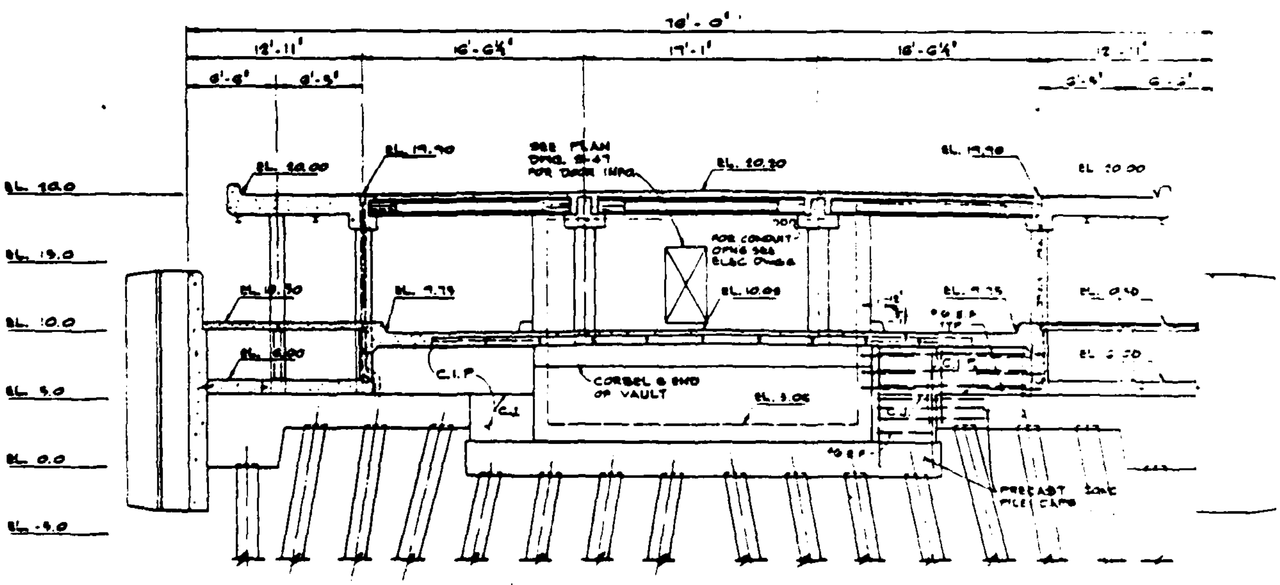
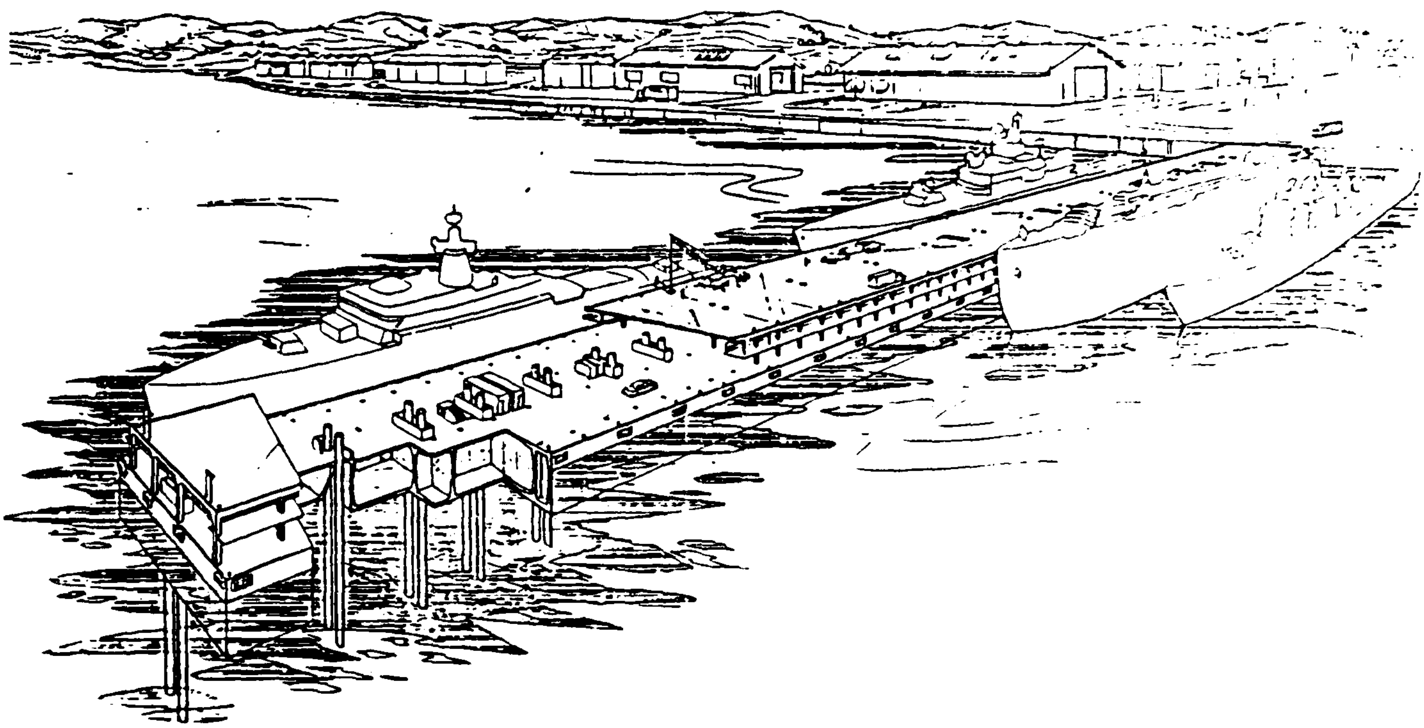


SECTION

Figure 1-1. Double-Deck, Pile-Supported Pier.



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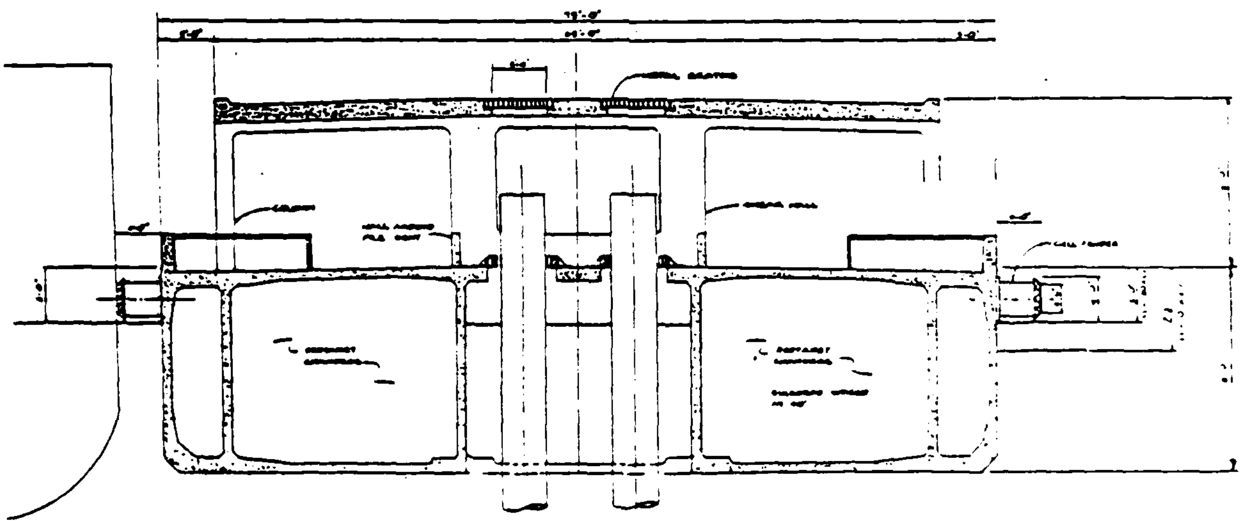


SECTION

Figure 1-2. Floating Pier.

from horizontal movement resulting from berthing loads and extreme environmental loads of a combined 90 mph wind and 6 knot current. The pier is free to move vertically with tidal variations.

The roof of the pontoon section functions as the lower deck. This deck provides space for small vehicle traffic, parking, general storage of equipment and material, and utility service equipment such as transformers, pipelines, trash containers, and salt water pumps.

The main deck is 65 feet wide and located 20 feet above the waterline. This deck provides space for operation of large equipment, such as truck cranes of up to 90-ton capacity, semi-trailer trucks, and delivery trucks. The functions performed on the main decks are cargo handling and refit operations. The main deck was designed to handle concentrated loads from crane outriggers without cribbing. It also was designed to be clear of most obstacles; however, electrical service mounds were located on the main deck for operational reasons.

Utility services to completely support berthed ships were provided from utility galleries on the lower deck. Electrical cables would be stored on reels or other storage medium on the lower level, and would be unreeled, and connected to the ships as required. Hoses, stored on the walkway, would also be connected to the outlets and fed to the ships without cluttering the main deck.

Wooden fender piles have been eliminated, and log camels reduced or eliminated. Modern cell fenders of the buckling cylinder type were selected.

Both the Naval fleet and shore establishment benefit from the floating pier concept. The following advantages itemize several of the benefits which are unattainable by conventional, fixed pier structures:

- <u>Save Downtime of Piers Being Replaced</u>

The Navy not only builds piers at new sites, but also replaces old piers, many of which were built 40 years ago during World War II. Replacing piers in a congested port system, can be more costly and time consuming than building new piers and, from a fleet support standpoint, is less desirable because an operational pier has to be taken out of service for the duration of the construction period. The downtime for the operational pier is on the order of 18 months because additional time is needed for the old pier to be removed before the new pier can be built. Replacing the old pier with a floating pier can reduce the downtime by some 12 months. The reason for the time savings is that the floating pier can be built at an offsite location prior to demolition of the old pier. Only after the floating pier has been built, including outfitting with utility systems, is the old pier demolished. The new pier is towed to the site, probably as two units, and the units are joined together. The pier is anchored and the utility systems connected to land. These operations can be accomplished within a 6 month period. The shore establishment gains from the short downtime for the pier replacement, and the fleet gains from improved readiness.

- <u>Advantages of Offsite Construction</u>

The shore facility benefits from the offsite construction of the pier because major construction operations are conducted away from the base. Congestion is reduced. A typical Naval base is not a convenient location to build a pier because of lack of

space for shore staging areas and because of base security restrictions of traffic flow for workers and material delivery.

Several construction methods are available to build floating piers, including construction at alternate sites where costs may be substantially lower, thus promoting competitive bidding. Conventional construction methods for fixed piers is site specific and generally involves a basic construction approach. For floating piers the construction methods of using a drydock, launching way, flood basin, or construction barge can be used. Also, a novel construction method has been conceived, which permits the pier to be build in a floating mode. This construction approach uses a floating form which allows for incremental casting of 40-foot long segments of the pier. Pier units of various lengths can be cast, for example 400- or 600- foot long or, if appropriate, even a continuous 1200-foot long unit can be cast. This single unit would probably be built at the final construction site, where towing would not be required. Once the floating form has been built, it is available for subsequent construction projects and it can be towed to other harbor sites which do not have existing flood basins or drydock facilities.

- <u>The Advantages as a Navy Pier</u>

The floating pier provides a structure well suited to the berthing and servicing needs of combatant ships. Thus:

- The pier structure rides the tide along with the berthed ship. This means the mooring lines, brows, hoses, and electrical cables connecting the pier with the ship will vary little in suspended length. Pinching of hoses or cables

between the ship and pier should not occur. In areas where major tide changes occur, mooring lines can be taut and do not need to be tended as the changes occur.

- The floating pier is a natural structure for having two deck elevations. The roof of the pontoon section is located near the waterline and forms a natural lower working deck. An elevated main deck can be built to match ship deck elevations. Pier functions can be separated between the lower and the main decks; hence, a relatively narrow pier can provide a large, usable deck area. In addition, the most valuable deck space is along the perimeter of the pier next to the ship. A two-deck arrangement has twice the perimeter space of a single deck pier. This is a highly significant feature. To illustrate, a two-deck pier of 65-foot width may have far greater servicing capability than a single deck pier of 130-foot width.
- Utilities can be located under the main deck. Full access to these utilities is provided from the lower deck. Considerable space is available for expansion of the utility systems.
- A modern cell type fender system can be used. The fender system can be designed to contact the ship hull at the waterline because the pier and ships move together with the tide. The system can eliminate the typical wooden pile fender system and reduce camel requirements, which are high maintenance items. See figure 5-8.
- Accidental damage to some ship components, such as propeller guards and sonar domes, would be prevented by eliminating

fender piles. The floating pier uses only guide piles located along the centerline of the piers.

- Adaptability to Different Site Conditions

  The floating pier is adaptable to various site conditions. For typical sites where tidal variation, water depth, and soil strength are within normal range, piles can be driven to restrain horizontal movement of the pier. For those sites where the tidal variation or water depth is large or where soil conditions are unsuitable for piling, mooring chain and anchors or stake piles can be used to restrain the pier.

- Better Earthquake Resistance

  The floating pier can better survive a major earthquake than a fixed pier. If the floating pier is anchored on location by mooring chains, the structural response to ground motion is significantly reduced or eliminated, and damage would be minimized. If guide piles anchor the structure against horizontal forces, major ground motion could buckle the piles. However, the pier would still be floating and operational. The damaged piles would provide some horizontal restraint until auxiliary mooring lines could be installed. Earthquake damage may not incapacitate a floating pier, as it could a pile-supported pier.

- Water as Energy Absorber

  A floating pier, that is not in a restrained position; i.e., taut chain, etc., moves horizontally during ship impact, using the water environment to absorb a substantial portion of the ship berthing energy. Such movement may displace large volumes of water, which dissipates energy. Displacement of water from

between the ship's hull and the underwater portion of the pier also absorbs energy.

- <u>Mobility of Floating Pier</u>

  The floating pier can be relocated within the harbor or to distant sites. As new designs of Naval vessels evolve, this mobility will enable the naval base to respond to the changing requirements of the Fleet. Present fixed piers prohibit this flexibility. Once this capability exists, obsolete piers at prime locations can be moved to less important sites, allowing new modern piers to be installed in their place. Relocation of piers can become a regular feature of future Navy ports.

  During times of national emergency, piers may be required to rapidly upgrade advanced bases. The response time of relocating an existing pier to a new site would be considerable less than that of building a new pier onsite.

Disadvantages exist with any concept, and it is important to acknowledge and consider the shortcomings of floating piers in their assessment. The following disadvantages are noted:

- <u>Higher Initial Cost</u>

  The floating pier will have a higher initial cost than that of a fixed pier for the following reasons:

  - Larger quantities of material are required to fabricate the pontoon sections which support the main deck of a floating pier than are required to support the deck of a fixed pier.
  - For a two-deck pier, as proposed herein, more deck area may be provided than actually required. A single-deck fixed

pier may meet working deck area requirements at a width of, say, 120 feet. The two deck concept will provide a width of 75 + 65 = 140 feet, whether required or not.

- Poor quality construction will have more severe consequences for the floating pier than the fixed pier. Additional quality control procedures and inspection will be required beyond those services usually specified.

Although initial costs are expected to be higher, the overall life cycle cost (LCC) for the floating pier has been estimated to be lower than the cost of a conventional single-deck, pile-supported pier. Refer to section 10 for analysis.

• <u>Require More Inspection</u>

During the floating pier's operational life, it will require more inspection than a fixed pier. The buoyancy chambers will require periodic inspection for leakage, and the anchoring system will require cathodic protection, maintenance, and inspection.

• <u>Interface Problem Between Pier and Shore</u>

The pier-shore interface could present the following problems:

- Level-adjusting ramps will be required to span the separation between shore and pier. The slopes have to be kept gentle, say below 1 to 10, for some equipment.
- The utility pipes must span the interface and accommodate vertical movement from tides and horizontal movement from jerking forces and environmental loads. Inspection and periodic replacement of flexible hose sections for the utility pipes will be required.

- The ramps must accommodate horizontal movement, both laterally and longitudinally, during an earthquake or ship collision.

- <u>Pier Movement</u>

  The floating pier moves in response to static and dynamic loads. This motion is likely to be slow, but still must be allowed for in all operations on the pier.

1.4 Point of Contact.

The point of contact for information covered in this Guide is Mr. Duane Davis, Project Manager, Code L55, Naval Civil Engineering Laboratory, telephone Autovon 360-4408 or commercial (805) 982-4408.

SECTION 2

PIER CONFIGURATION AND DIMENSIONS

NAVFAC P-80 and DM-25.1 contain information and criteria concerning pier length, width and water depth. Neither address the basic determination of configuration or deck area requirements.

This section discusses planning the basic configuration of the pier, water depth requirements, pier length, deck area requirements, determination of pier width, and establishing the optimum deck elevation.

2.1 Pier Configuration

Pier planning and design documentation and definitive designs address only the historical single-deck berthing pier. NAVFACENGCOM has developed conceptual designs for double-deck piers, and one recent MILCON project, Pier Zulu, NAVSTA, Charleston, SC resulted in a double-deck design. Planning for each pier design should give full consideration to the range of pier types and configurations; floating, double-deck pier and fixed, pile-supported single and double-deck configurations.

2.1.1 Objectives. In determining pier configuration, the following objectives should rule:

a. The pier must fit the site and be practical to construct.

b. The pier must be functionally efficient and serve the ships with a minimum of delay and labor requirements. The fundamental objective here is a "clear" main deck.

c. The life cycle cost of the pier must be favorable. Lower initial cost should not be the sole objective. See section 10 for the life cycle cost approach.

d. The pier must be flexible and adaptable to retrofit, expansion and change. Ships and weapon systems go through several generations during

the life expectancy of the pier. To remain responsive, the pier must be capable of economical change.

2.1.2 Operational Factors. While normal engineering considerations such as water area available, land area for shore-pier interface, tide and current conditions, depth of water, and soil subsurface conditions will govern the design, operational factors should largely influence the pier configuration.

a. Types of Ships. The range and mix of ship types to be accommodated must be estimated. Many design decisions will be dictated by the weighted ship mix and some by the most stringent ship requirements. Since the pier is to serve for some 25 to 40 years, this planning should look to future ship homeporting rather than only current ship types.

b. Functional Demands. Similarly, an estimate of the predominate functions to be performed and predicted tempo is useful in this planning. At most homeporting activities, this question will resolve to one of level and frequency of Phased Maintenance Activities (PMA) to be performed at the pier (see paragraph 2.4.2). Significant PMA functions will drive a number of design decisions including selection of pier configuration. Other influencing functions that should be investigated are ordnance loading/unloading and ship fueling requirements.

2.1.3 Characteristics, Advantages, and Disadvantages of Configurations.

a. Floating Pier.

- Natural double-deck design. See double-deck, fixed pier.
- Adaptable to deep water sites.
- Allows considerable offsite construction reducing existing pier downtime and site congestion.
- Ship-to-pier relative elevation remains constant.

- Better earthquake resistance.
- Due to varying elevation, requires complex ramp design and shore-to-pier utility interface.
- May be relocated to different site.
- Requires flood basin, graving basin or drydock for construction.
- Higher initial cost, competitive life cycle cost.

b. Single-Deck, Fixed Pier.

- Width significantly greater than double-deck pier. Requires sufficient water area and slip width.
- Requires less adjacent land area for shore-pier interface.
- Difficult to maintain clear, unrestricted deck.
- Constant conflict between utility operations and other functions; primarily crane operations. See figure 2-1.
- Less flexibility for future change/expansion.
- Initial cost comparable to double-deck pier, but higher life cycle cost.

c. Double-Deck, Fixed Pier.

- More pier space in less width.
- More usable deck area per unit cost.
- Doubles ship-to-pier interface.
- Enables design of full utility gallery. See section 6.
- Higher main deck elevation. See paragraph 2.5.
- Requires more adjacent land area for access ramps.
- Separation of functions can improve efficiency.
- Lower life cycle costs.

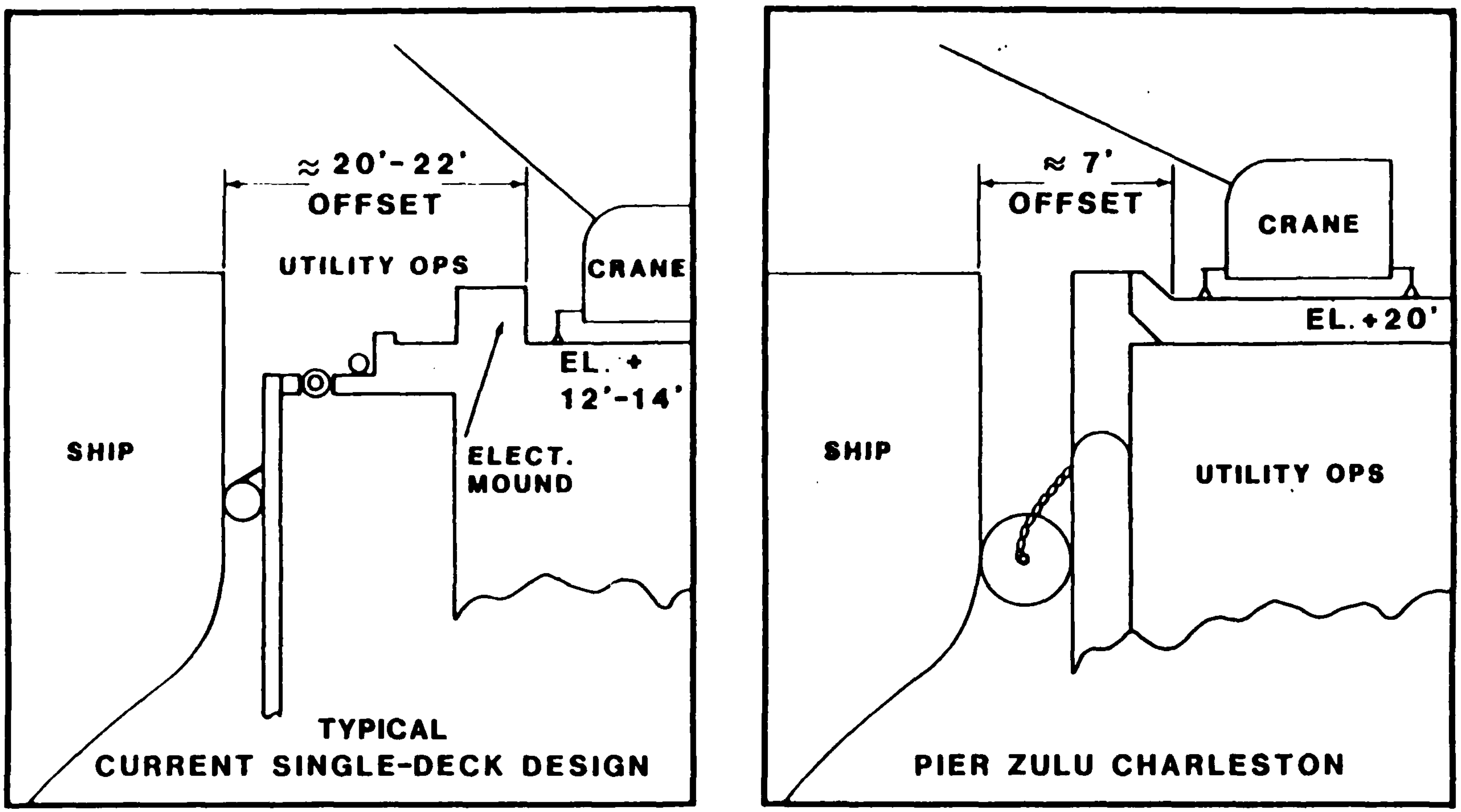


Figure 2-1. Double-Deck Pier Crane Operations Advantage.

2.2 Water Depth in Slips

DM-25.1 provides criteria for minimum depth of water relative to the draft of ships and other considerations. Caution is advised in use of the maximum navigational drafts contained in NAVFAC P-80, table 151-10 and DM-25.1, table 1. Actual drafts of ships in the Fleet may exceed the drafts shown. As an example, the record draft of the CG-47 class Guided Missile Cruiser is 31 feet 7 inches, while the actual draft of the USS TICONDEROGA was informally reported as 33 feet.

When designing specific piers, it is recommended that actual "working" drafts of appropriate ships be requested from Type Commanders.

2.3 Pier Length

DM-25.1 requires a multiple berth pier length that allows 100 feet between ships and 50 feet clear of either end of the pier. A pier berthing two ships, with a DD-963 hull (CG-47, DDG-993), on one side would require a nominal length of 1330 feet. A number of factors influence the pier length including site conditions, water depth, distance from ship channel, and other pier structures. The clear distances specified between and at the end of berths is seldom available in practice. For example, the more recent Navy pier design for berthing of medium surface combatant ships, Pier Zulu, Charleston, provides a nominal clear berthing length of 1244 feet.

For purposes of conceptual designs, and the deck area discussion in paragraph 2.4, for the types of ships considered here, a berth is established as 600 feet in length with a four berth pier providing 1250 to 1300 feet clear berthing length.

2.4 Deck Area Requirements and Pier Width

This discussion derives from work on design concepts for small and medium surface combatant ships. It is considered equally valid for those sets

of amphibious and auxiliary ships with overall lengths under 600 feet and no unique overhang configurations. DM-25.1 provides guidance for minimum pier widths to serve these size ships as follows:

Berthing pier	80 feet
Fitting-out pier	100 feet
Repair pier	125 feet

All three functions are being performed on what was formerly termed berthing piers. The space requirements for most piers now, and in the future, will likely be that required to serve fitting-out functions and certain levels of ship repair.

Recent Navy single-deck piers have been in the range of 120 feet wide with the outer 15-17 feet on either side essentially dedicated to utility operations. As a result, crane operations and other functions are constrained by the utility "corridors" and there is continual contention for space contiguous to the ship. Additional pier width will not solve the problem.

2.4.1 Functional Space Requirements. The determination of space requirements is based upon observations of current operations on existing piers and calculated space requirements developed in conceptual designs. In this discussion, pier width refers to the dimension perpendicular to the ship and pier length is parallel to the ship. Table 2-1 lists the dimensional and area requirements for the major functions on a typical single-deck pier. The following are pertinent to the dimensions in table 2-1:

- Space for bollards and mooring lines takes first priority on the pier. The area required is along the pier edge and is dedicated.

Table 2-1. Space Requirements for One Berth on Single-Deck Pier.

PIER FUNCTIONS	DIMENSIONS REQUIRED		AREA	REMARKS
	PIER WIDTH	PIER LENGTH	(SQ FT)	
1. Mooring Lines	4' in area of bollard	4'-bow, stern and breast lines. Up to 30'-spring lines	2400	Allows a 4' corridor along the pier for lines and line handlers. Lines terminate at bollards adjacent to pier edge.
2. Personnel Access	25'	15'	375	Varies with height of pier deck. Typical brow and platform for combatant shown. Two locations sometimes required.
3. Utility Services	8' to 15' currently used. Good design should be not more than 12'.	Based on pier concept designs:		Lengths are outside limits. Area based on 12' width is not totally utilized but is constrained.
		CG-47 = 190'	2280	
		DD-963 = 214'	2658	
		FF-1052 = 198'	2376	
		FFG-7 = 151'	1812	
		AD-41 = 496'	5952	
4. Crane Service	30' for 70 ton and 35' for 100 ton mobile crane; allows clearance.	Up to 100'. Crane parallel to ship. Allows for load on pier.	3000 to 3500	May occur anywhere along berth. Concentrated service in middle half of berth.
5. Vehicle Access to Ship	From edge of pier to inboard of vehicle, including clearance for offloading = 25'.	Up to 60' for cargo tractor-trailer.	1500	May occur anywhere along berth.
6. Fire Lane	30', 15' lane either side of centerline.	Entire length of pier.	36,000	Area for 1200' length of pier.
7. Training Van	28' for 20B5 trainer.	63'	1764	Optimum location is close to amidship. See figure 2-2.
8. Maintenance Activities:				See paragraph 2.4.2. Utility area is additional as shown above.
IMAV	30'	100'	3000	
PRAV	35'	310'	10,800	
SRA	35'	515'	18,000	
ROH	35'	660'	23,000	
9. Miscellaneous:				
Solid Waste	2 at 8'	2 at 20'	320	In between berths.
Ship Vehicles	30'	30'	900	Three vehicles.
Bike Storage	8'	40'	320	

- Space required for personnel access is for one typical brow and platform.
- The lengths of utility service areas are based on the distance between ship service points closest to the bow and stern. The width of pier required for utility service is based on observation of existing piers. A 12-foot clear width inside bollards is considered adequate.
- Crane service area is based on a 70 to 100-ton crane positioned parallel to the ship.
- Vehicle access is for tractor-trailer and buses to park adjacent to the ship and unload.
- The fire lane and general traffic truck lanes down the center of the pier are the same area. DM-25.1 does not address fire lanes, but calls for truck lanes of a minimum of 12 feet and preferably 15 feet.
- Training van space is taken from figure 2-2.
- Maintenance activities areas are from paragraph 2.4.2.
- The miscellaneous areas shown are from observation of current practices.

2.4.2 Phased Maintenance Activities. At certain Navy ports, PMA performed at berthing piers will be of significant magnitude. Requirements, including space and dimensional criteria, should be considered when determining pier dimensions for specific designs at these locations. The four levels of PMA include:

- Intermediate Maintenance Availability (IMAV), consisting of removal and repairs of shipboard equipment performed by Shore Intermediate Maintenance Activity (SIMA) personnel or tender forces, with a timeframe of approximately 30 days.

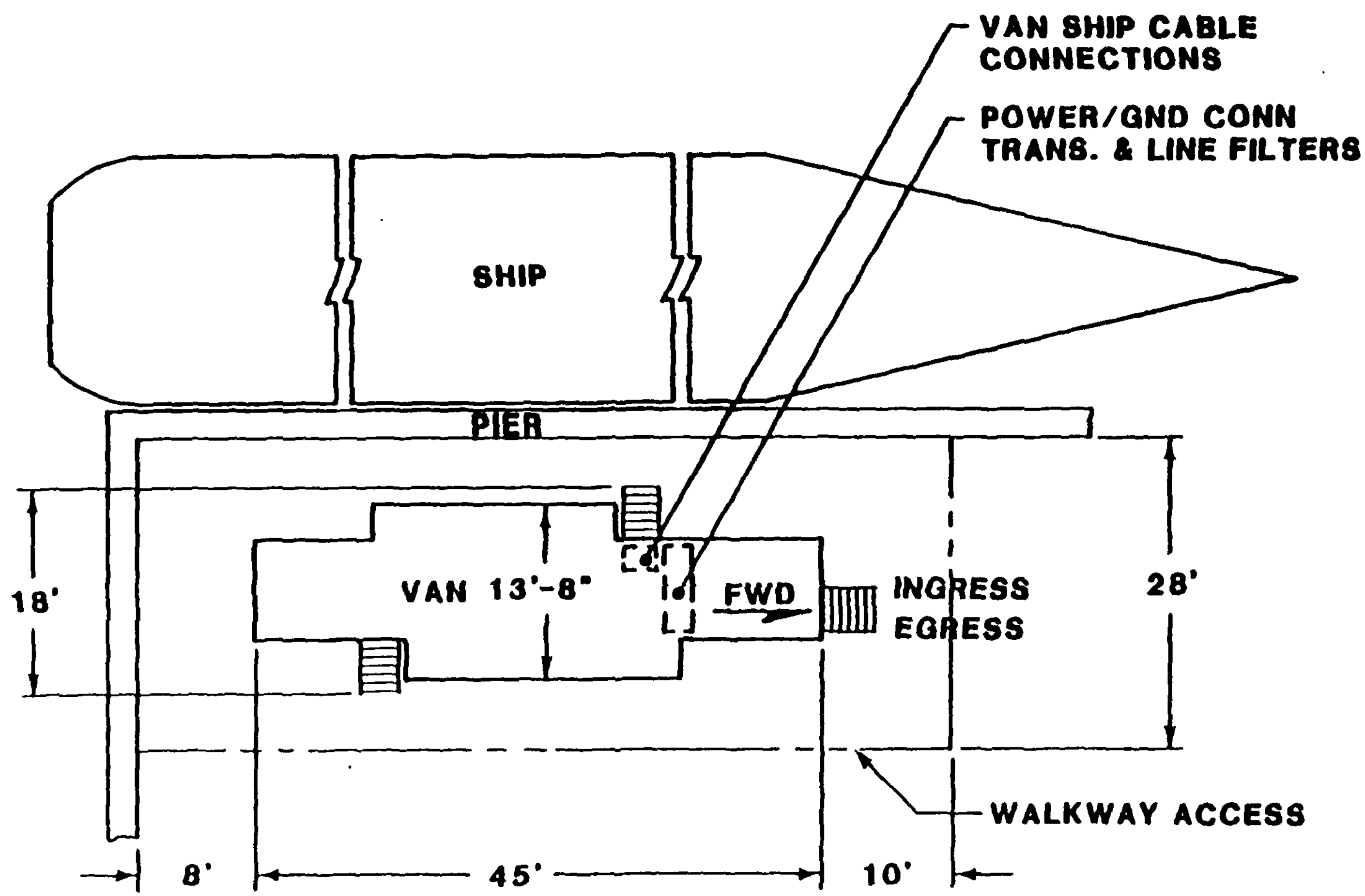


Figure 2-2. Training Van Pier Space Requirement.

- Planned Restricted Availability (PRAV), consisting of limited repairs of shipboard equipment and systems by contract forces under Supervisor of Shipbuilding and Repairs (SUPSHIP) control, with a duration of 30 to 60 days.
- Selected Repair Activity (SRA), consisting of expanded repairs and/or minor ship alterations to shipboard equipment and systems by SUPSHIP contract forces, with a duration of approximately 60 days.
- Restricted Overhaul (ROH), consisting of major repairs and/or ship alterations to shipboard equipment and systems by SUPSHIP contract forces, with a time factor of 6 to 8 months.

Preliminary investigation and analysis of pier space requirements for PMA have been made and are included here for guidance and example. Site specific requirements should be applied to individual pier designs.

a. Pier Deck Area Requirements. The following are estimated space requirements. Functional breakdowns for the higher three levels are shown in tables 2-2, 2-3, and 2-4.

IMAV: Gross deck area requirements equal 2000 to 3000 square feet (ft^2). Work area dimensions will vary from 30 feet x 65 feet to 30 feet x 100 feet.

PRAV: Gross deck area requirements are approximately 10,800 ft^2 (35 ft x 310 ft) dedicated to PRAV activities. On a double-deck pier, approximately 2000 ft^2 of command and storage area could be on the lower level.

SRA: Gross deck area requirements are approximately 18,000 ft^2 (35 ft x 515 ft) dedicated to SRA activities. On a double-deck pier with adequate clearance, approximately 5,000 ft^2 of command and operational area

Table 2-2. Pier Space Requirements for Planned Restricted Availability.

FUNCTIONAL AREA	REQUIRED PIER AREA (ft^2)
COMMAND AREA	
Parking Area (12.5 ft x 20 ft)	250
Bicycle rack (8 ft x 9 ft)	70
	320
OPERATING AREA	
Dumpsters, solid and hazardous waste (12 ft x 12 ft x 8 ea)	1,150
Air compressors (12 ft x 12 ft x 2 ea)	290
Welding area (30 ft x 50 ft)	1,500
Flammable Storage (10 ft x 15 ft)	150
Transportation laydown area (20 ft x 30 ft)	600
Crane work area (35 ft x 110 ft)	3,850
Offload area-oil, fuels, etc. (30 ft x 100 ft)	3,000
	10,540
Total	10,860

Table 2-3. Pier Space Requirements for Selected Repair Activity.

FUNCTIONAL AREA	REQUIRED PIER AREA (ft^2)
COMMAND AREA	
Mobile admin. buildings (20 ft x 70 ft x 2 ea)	2,800
Parking area (12.5 ft x 20 ft)	240
Bicycle racks (8 ft x 9 ft x 2 ea)	140
	3,190
OPERATING AREA	
Demineralizer (12 ft x 40 ft x 1.5 ops factor)	1,500
Bilger water/stripping tank (10 ft x 20 ft x 2 ops factor)	400
Dumpsters, solid and hazardous waste (12 ft x 12 ft x 10 ea)	1,440
Portable solid state generators (12 ft x 10 ft x 2 ea)	240
Air compressors (12 ft x 12 ft x 2 ea)	290
Welding area (30 ft x 50 ft)	1,500
Flammable storage (20 ft x 30 ft)	600
Transportation laydown area (30 ft x 30 ft)	900
Crane work area (35 ft x 110 ft)	3,850
Offload area-oil, fuels, etc. (30 ft x 120 ft)	3,600
Portable heads (6 ft x 6 ft x 2 ea)	70
Additional brow (20 ft x 20 ft)	400
	14,790
Total	17,980

Table 2-4. Pier Space Requirements for Restricted Overhaul.

FUNCTIONAL AREA	REQUIRED PIER AREA (ft^2)
COMMAND AREA	
Mobile admin. buildings (20 ft x 70 ft x 2 ea)	5,600
Parking area (12.5 ft x 20 ft)	500
Bicycle racks (8 ft x 9 ft x 2 ea)	200
	6,300
OPERATING AREA	
Demineralizer (12 ft x 40 ft x 1.5 ops factor)	1,500
Bilger water/stripping tank (10 ft x 20 ft x 2 ops factor)	400
Dumpsters, solid and hazardous waste (12 ft x 12 ft x 10 ea)	1,730
Portable solid state generators (12 ft x 10 ft x 2 ea)	240
Air compressors (12 ft x 12 ft x 2 ea)	290
Welding area (30 ft x 50 ft)	1,500
Flammable storage (20 ft x 30 ft)	600
Transportation laydown area (30 ft x 30 ft)	1,500
Crane work area (35 ft x 110 ft)	5,250
Offload area-oil, fuels, etc. (30 ft x 120 ft)	4,500
Portable heads (6 ft x 6 ft x 2 ea)	70
Additional brow (20 ft x 20 ft)	400
	16,920
Total	23,220

could be on the lower level reducing main deck requirements to 13,000 ft^2 (35 ft x 370 ft).

ROH: Gross deck area requirements are approximately 23,000 ft^2 (35 ft x 660 ft) dedicated to ROH activities. In addition, there would be a requirement for turnaround areas on the pier and warehousing off the pier. On double-deck pier with adequate clearance, up to 8000 ft^2 of command and operational area could be on the lower level with the potential for reducing the main deck requirement to a space measuring approximately 35 ft by 430 ft. These space requirements and certain functional operations establish the minimum pier width requirements discussed in paragraph 2.4.4.

2.4.3 Deck Area Requirements Applied to a 600-Foot Berth. The following figures illustrate the major space requirements from table 2-1 applied to a 600-foot long berth on both a single-deck and double-deck pier:

Figure	Illustration
Single-Deck Pier	
2-3	Normal Operations
2-4	IMAV
2-5	PRAV
2-6	SRA
2-7	ROH
Double-Deck Pier	
2-8	Normal Operations
2-9	IMAV
2-10	PRAV
2-11	SRA
2-12	ROH

2.4.4 Pier Width. The width dimensions shown in figure 2-3 through 2-12 were determined as follows.

a. Single-Deck Pier Width. Day-to-day pier operations are a conglomeration of training, supply, housekeeping, and readiness functions. Figure 2-3 is an arrangement for a single-deck pier, similar to recent Navy designs, depicting the functions that require the most space. The dominant space requirement is the area occupied by utility service outlets and the utility working area. In the latest Navy single-deck pier designs, this function occupies a dedicated corridor immediately adjacent to the ship. As shown in table 2-1, the minimum length of the corridor is the distance between extreme ship utility service points. For a DD-963, a length of 214 feet in the midsection of the berth is required. From observation of utility operations, a width of 12 feet inside bollards is adequate for this corridor.

For many crane lifts, the crane must be positioned outside the utility corridor, so the width-determining factors become the area occupied by

bollards and mooring lines, the utility service area, crane working area, and fire lane. An optimum single-berth width of 61 feet results:

4 ft	outer width for curb, bollards and mooring lines
12 ft	utility area
30 ft	crane area
15 ft	fire lane
61 ft	

This layout, provided for berths on both sides of the pier, results in a pier design which is 122 feet wide.

When ship maintenance activities are considered, the significant width requirement increase is for the use of larger capacity cranes of 100-115 tons. The working area increases to 35 feet. For purposes of illustration in figures 2-4 through 2-7, a fire lane of 12 feet, the minimum permissable, is used which results in a single-berth width of 63 feet and a potential pier width of 126 feet.

As evident from figure 2-7, conducting an ROH on a single-deck pier is not projected as effective or economical. Extensive off-pier space is required. Increasing the width of the pier and "stacking" functions horizontally away from the ship is ineffective. The lower PMA levels can be accommodated on a 600-foot long by 63-foot wide berth, but operations will be constrained by the dedicated utility corridor.

In summary, the optimum single-deck berth width (to the centerline), using a 12-foot fire lane, is 63 feet. If pier width is constrained and this width cannot be provided on both sides of the pier, the fire lane can be shifted during crane operations toward the opposing berth. A single-deck pier width of 120 feet, with two 12-foot fire lanes, will allow space for PMA through the SRA level on one side (figure 2-6) and unconstrained normal, day-to-day operations (figure 2-3) at the opposing berth.

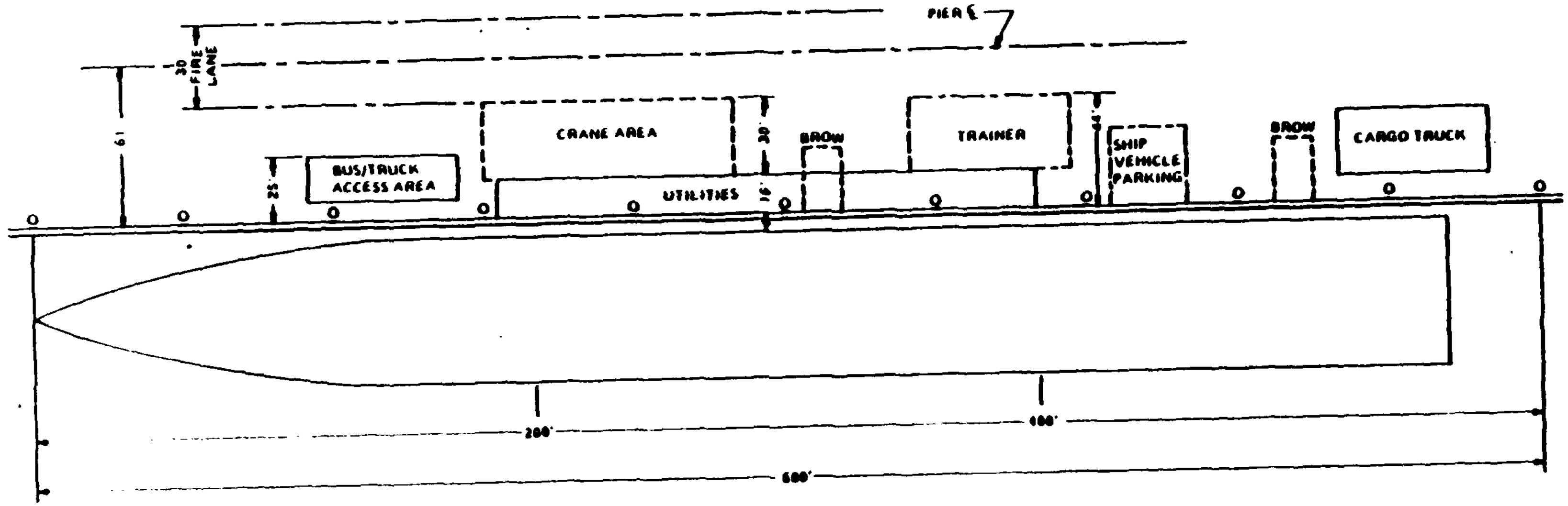


Figure 2-3. Space Requirements for Normal Operations - Single-Deck Pier.

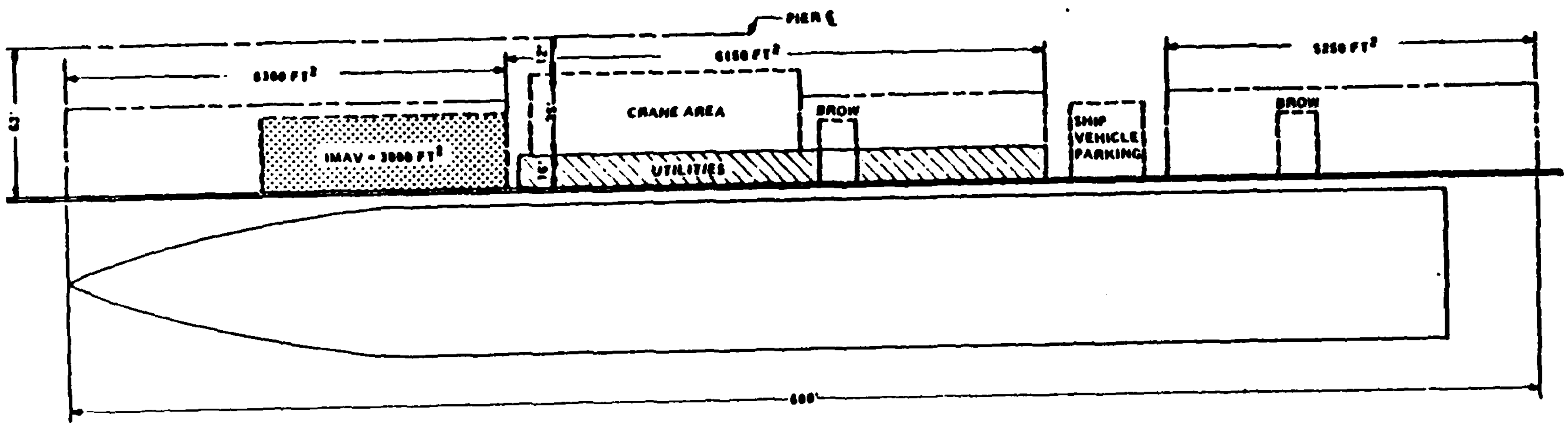


Figure 2-4. Space Requirements for IMAV - Single-Deck Pier.

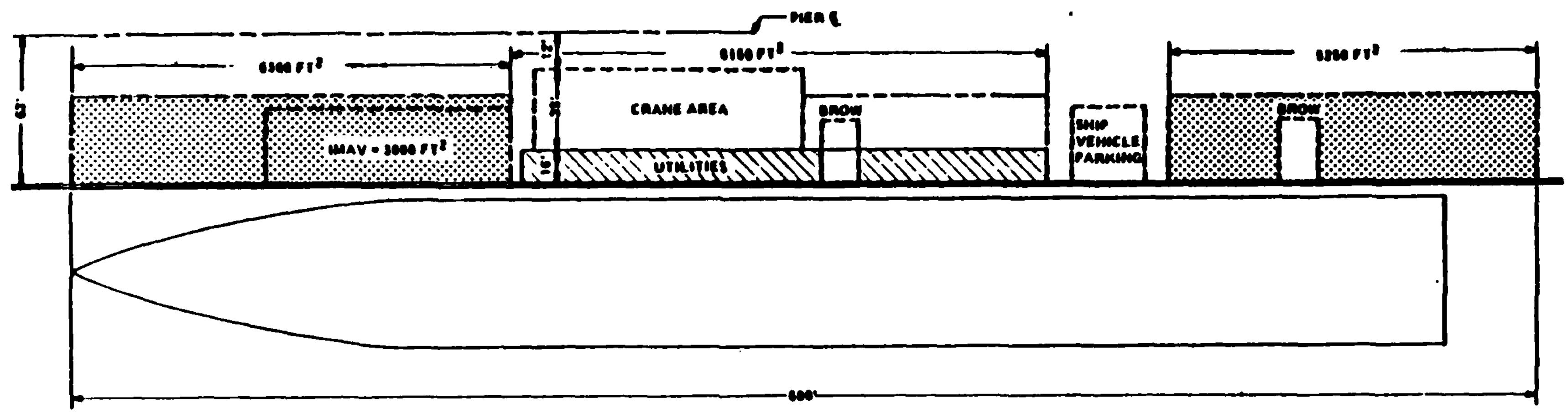


Figure 2-5. Space Requirements for PRAV - Single-Deck Pier.

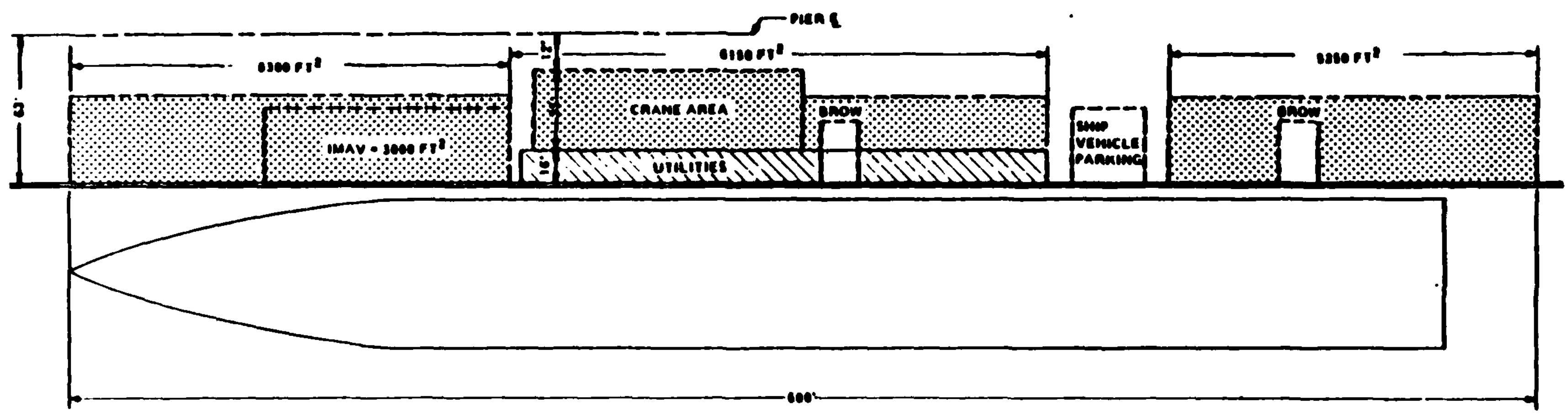


Figure 2-6. Space Requirements for SRA - Single-Deck Pier.

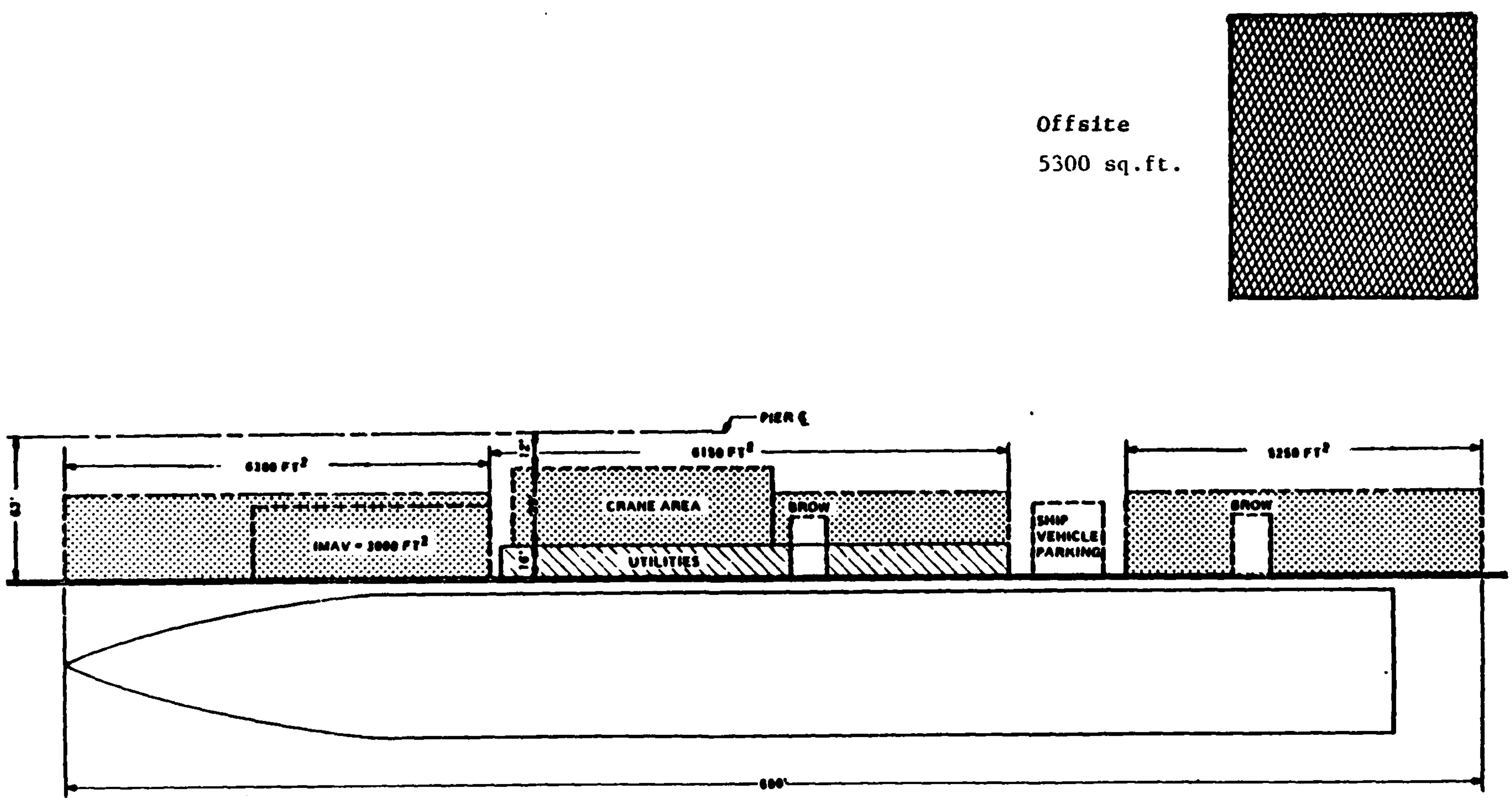


Figure 2-7. Space Requirements for ROH - Single-Deck Pier.

b. Double-Deck Pier Width. The double-deck pier designs developed in the Port Systems Project and Pier Zulu, Charleston, move the entire utilities functions to a lower deck. In addition, other functions may be located on the lower deck, such as solid waste containers, certain types of vehicle traffic, some cargo deliveries, and vehicle parking. Due to the higher deck elevation, platforms supporting personnel brows, are eliminated in most cases, further clearing the main deck. Also, functions on the main deck gain direct access to the edge of the pier since the utility functions are no longer occupying a dedicated "corridor."

Applying day-to-day functions that will be conducted on the main deck results in the layout of figure 2-8. Cranes can be positioned between bollards, so the width determining functions are crane operations plus the fire lane. The optimum width for a berth when a crane lift is conducted is 30 feet (crane working area) plus a 15-foot fire lane. If a 12-foot fire lane is used, the one berth width requirement is 42 feet.

Minimum PMA space requirements on the main deck of a double-deck pier are estimated to be (see paragraph 2.4.2):

IMAV	3,000 ft^2
PRAV	8,000 ft^2
SRA	13,000 ft^2
ROH	15,000 ft^2

Figures 2-9 through 2-12 allocate space to these activities on a double-deck pier with a 12-foot fire lane. A pier that provides 35 feet of space between the fire lane and curb on the main deck can accommodate all projected maintenance activities within the 600-foot berth. As shown by figures 2-11 and 2-12, there is considerable unallocated space within the berth for miscellaneous functions.

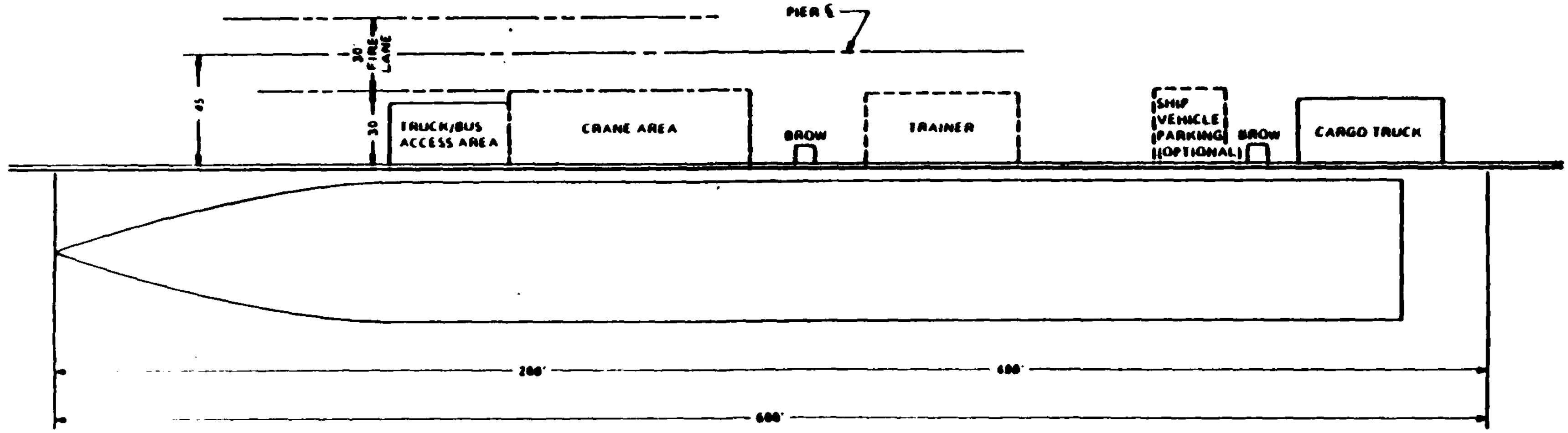


Figure 2-8. Space Requirements for Normal Operations, Main Deck of Double-Deck Pier.

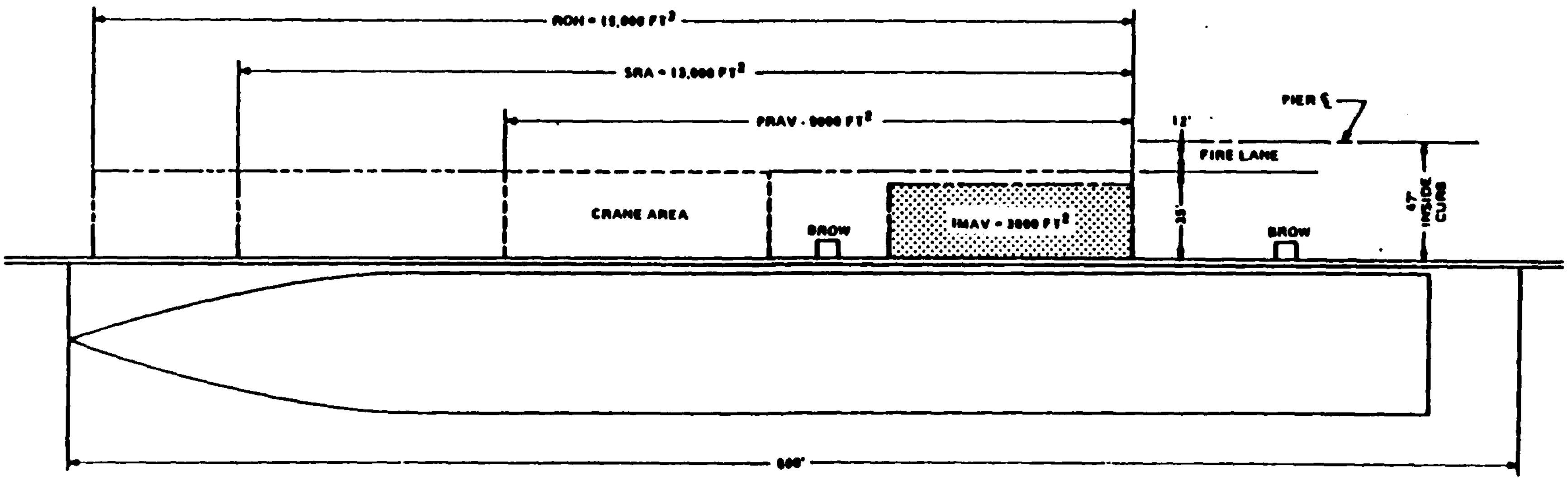


Figure 2-9. Space Requirements for IMAV - Double-Deck Pier.

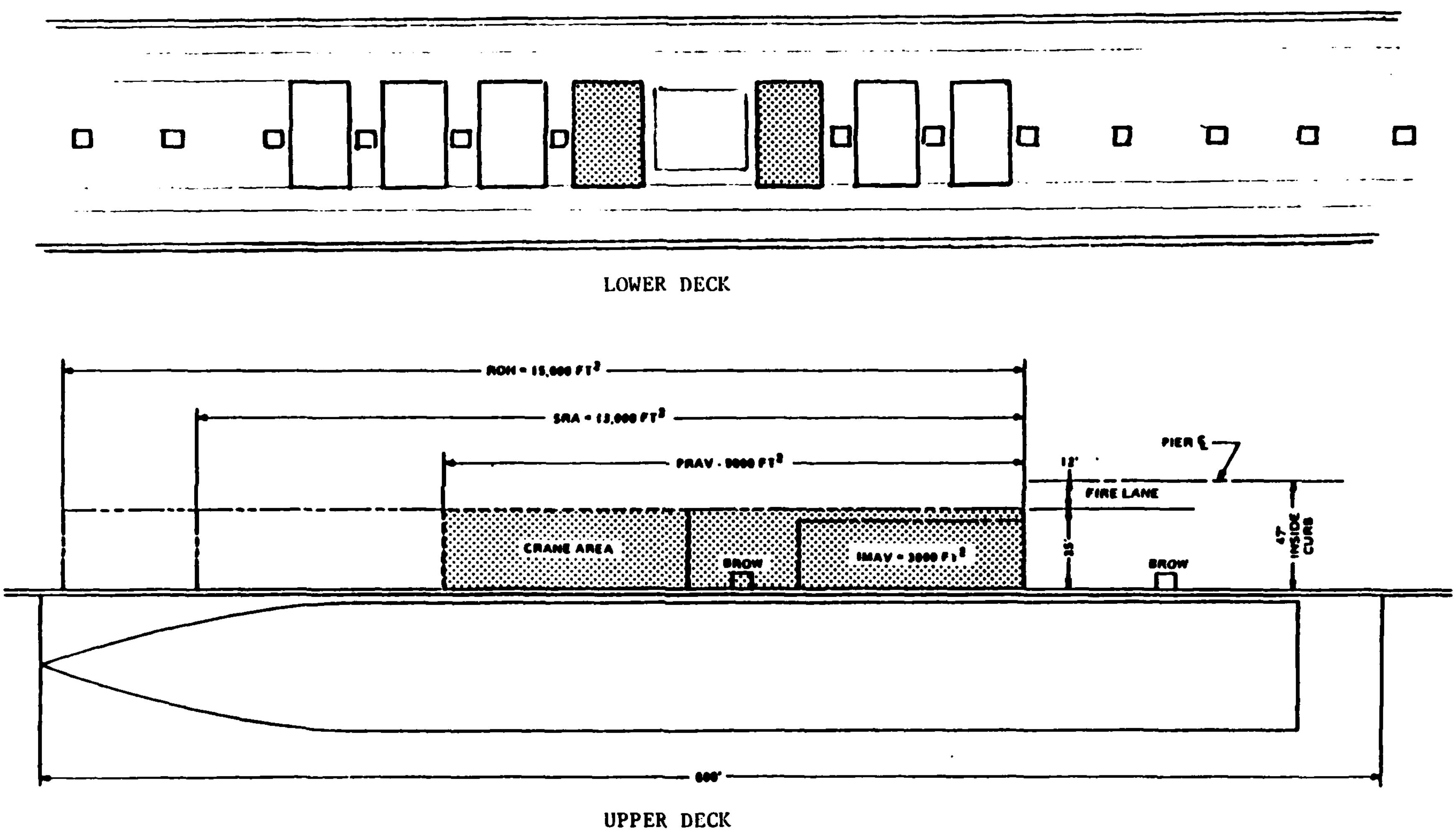


Figure 2-10. Space Requirements for PRAV - Double-Deck Pier.

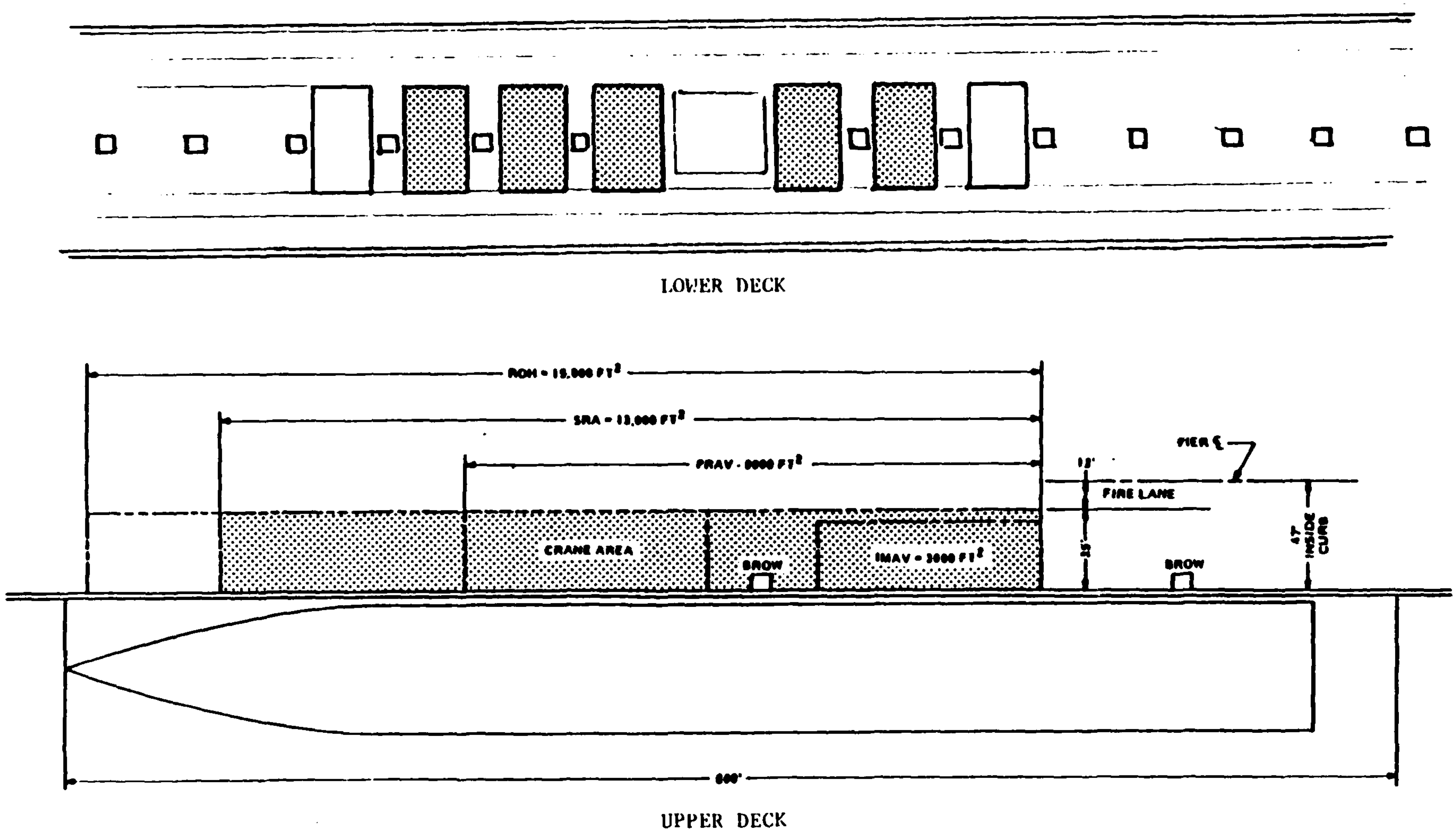


Figure 2-11. Space Requirements for SRA - Double-Deck Pier.

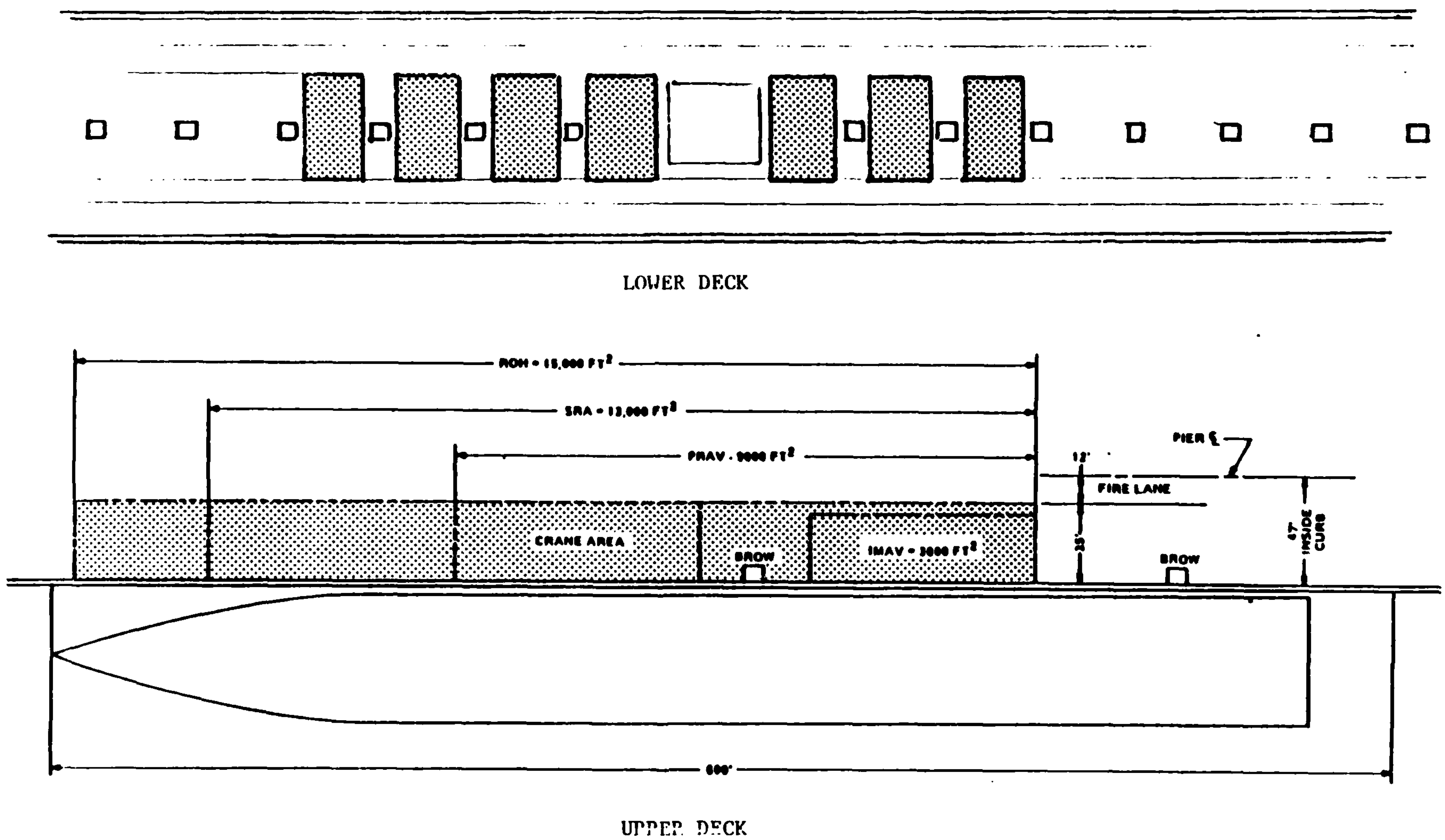


Figure 2-12. Space Requirements for ROH - Double-Deck Pier.

In summary, the optimum clear width of the main deck of a double-deck pier is 94 feet using two 12-foot fire lanes.

2.5 Pier Deck Elevation

In the determination of pier elevation, DM-25.1 states that consideration should be given to: (1) overflow, (2) ship freeboard, (3) upland areas at solid wharves, (4) adjacent land areas, (5) loading platforms, and (6) crane and railroad tracks. For piers to serve surface combatant ships, items (1), (2), and (4) are applicable.

Overflow: DM-25.1 requires the lowest point of the superstructure to be a distance above mean high water (MHW) equal to two-thirds of the maximum wave height, plus a freeboard of at least 3 feet.

Ship freeboard: Consider varying conditions of ship freeboard relative to the use of gangways, load/unload functions, crane service, etc.

Adjacent land: Deck elevations should conform to generally established levels.

Historical Navy practice has given precedence to the elevation of adjacent property after satisfying the overflow requirement. As a result, one primary question continues to surface. Why is it necessary for the pier elevation to "conform to levels of adjacent station property?" For finger piers, access by equipment can be satisfactory over a ramp of reasonable grade.

Within engineering practicality, the ship freeboard consideration should be paramount.

2.5.1 Determining Pier Deck Elevation. An objective, systematic evaluation of all pertinent factors is required to determine the optimum pier deck elevation. The evaluation should develop factors that are important in the local

berthing situation and assign relative weights or priorities. After necessary engineering considerations are satisfied, final deck elevation should be established to serve the ships.

Consideration must be given to the following site-specific factors:

- Tidal range.
- Number and types of ships to be berthed.
- Dominant pier activities including level of ship maintenance activities (see paragraph 2.4.2).
- The predicted mix of berthing evolutions; e.g., what is the tempo of daily or short range operations, what is the frequency of ship movements within the port between berths, etc.

The following functional factors are recommended for use in the evaluation:

a. Personnel Ingress/Egress. Currently, practically all ship exits are well above pier decks, requiring the use of platforms in conjunction with sizable brows. People go down to the pier and up to the ship. There is no apparent advantage to this configuration. A relatively level access requires much less deck area than high brows.

b. Crane Service. Cranes now work up to the ship from the pier. Working level with the ship main deck, or even down to the ship, appears to be more efficient.

c. Cargo Load/Unload. A level access for conveyors appears to be most efficient for movement either on or off the ship. Since more cube/weight is loaded than is unloaded, loading down to the ship would be an advantage. For most ships and piers, the load must now be moved up to the ship, with much of the cargo being hand-carried aboard.

d. Ship Restraint Lines. A relatively level ship-pier relationship, or the ship working down to the pier, appears to be preferable to tying lines "up" to the pier from the ship.

e. Utilities Connections. Utilities connections are critical to shipboard activities from the standpoint of (1) time to hook-up, (2) clearances of hoses and cables from other shipboard activities, access areas, lines etc., and (3) lengths of cables and hoses which affect voltage drops and line losses. The optimum pier elevation for utilities connections would be within $\pm$ 5 feet of ship utility connection points and would be based upon an average height of ship utilities hook ups with special considerations for those conditions that could lead to damage of cables, hoses, etc.

f. Protection of Utilities Systems. Maintaining sufficient elevation above water levels, including highest high water and surge tides, is critical for the protection of cables, hoses, and fittings. In the case of electrical vaults it is not uncommon to have vaults project 18 feet below the pier deck. Although vaults are designed to resist salt water intrusion, years of submergence could eventually lead to major seepage and potential damage to electrical equipment. Utility trenches and galleries are far more susceptable to salt water intrusion at lower elevations.

g. Pier Security. Elevation of the deck can affect visibility of pier areas from the ship, thereby in some cases, adversely affecting visual security.

h. Overflow Protection. See DM-25.1.

i. Adjacent Property Elevation. A high deck elevation, relative to adjacent property, will require longer approach ramps occupying land area.

2.5.2 Pier Elevation for Surface Combatant Ships. In the Pier Design Concepts project, a preliminary evaluation of pier deck elevation was made for small and

medium surface combatants. A series of scored evaluations were made for elevations between 12.5 and 25 feet above mean low water (MLW). The results were as follows:

Pier Deck Elevation	Weighted Score (Norm = 5)
12.5	4.38
16	5.00
20	5.25
25	4.90

The optimum elevation following this evaluation criteria would appear to be approximately 20 feet above MLW. Table 2-5 illustrates the scoring methodology used in this example.

This trial evaluation brought out the following advantages and disadvantages of a higher deck elevation:

ADVANTAGES:

- Eliminates many brow platforms.
- Decreases crane service for brows/platforms.
- Decreases pier congestion.
- Shorter utility lines, less height for placement.
- Shorter crane reach; smaller capacity crane may be used.
- Work down to, or level with, the ship.
- Manual cargo loading requires less labor/time.
- Less "work" for conveyors.
- Better overflow protection.

DISADVANTAGES:

- Steep angle of mooring lines; fender system interference.
- Steep angle of brow; platform may be required on ship.
- Line of sight from ship to pier not as good.
- Access from shore requires ramp which occupies adjacent land area.

Table 2-5. Scored Evaluation for Pier Elevation of 20 Feet.

PIER ELEVATION 20.0 feet

MLW = 0.0 MHW = 6.0 feet

FACTOR	WEIGHT	RAW SCORE	WEIGHTED SCORE	MEASUREMENT (BASIS OF EVALUATION	REFERENCE ELEV. RANGE	REMARKS
1. Ship Restraining System	0.10	5	0.50	Differential Elev. Ship/Pier @ MLW and MHW		
a. Fore					15-27 ft	Note 1
b. Aft					15-17 ft	Note 1
2. Cargo Transfer	0.15	4	0.60	Differential Elev. Ship/Pier @ MLW and MHW		
a. Fore					15-22 ft	Note 1
b. Aft					15-17 ft	Note 1
3. Ship Repair Activities	0.10	7	0.70	Differential Elev. Ship/Pier @ Decks and Highest Point @ MLW and MHW		
a. Brows/Conveyors					15-22 ft	Note 1
b. Highest Point					Not avail	Note 1
4. Personnel Movement	0.05	5	0.25	Diff. Elev. Ship/Pier (MLW & MHW)	16-24 ft	Note 1
5. Utilities Connection	0.15	6	0.90	Diff. Elev. Ship/Pier @ MLW and MHW		
a. Electricity					25-50 ft	Note 1
b. Steam					16-35 ft	Note 1
c. Fresh Water					16-35 ft	Note 1
d. Salt Water					16-25 ft	Note 1
e. Compressed Air					16-35 ft	Note 1
f. CHT					16-25 ft	Note 1
g. Oily Waste					16-25 ft	Note 1
6. Protection of Util. Sys	0.15	7	1.05	Elev. above MHW		
a. Utilities Galleries					6-10 ft	Note 2
b. Elect. Vaults/Pump Sta					(-) 6-3 ft	Note 2
7. Pier Security	0.05	4	0.20	Diff. Elev. Ship/Pier (MLW)	16-24 ft	Note 1
8. Adjacent Property	0.15	3	0.45	Diff. Elev. Pier/Land	10-16 ft (av)	Note 3
9. General Overflow Protection	0.10	6	0.60	Elev. above MHW	14 ft	Note 2
	1.00		5.25			

Notes:
1. Reference elevation range based on ship height above Design Water Line (DWL).
2. Reference elevation range based on pier height above or below Mean High Water (MHL).
3. Reference elevation range based on adjacent property.

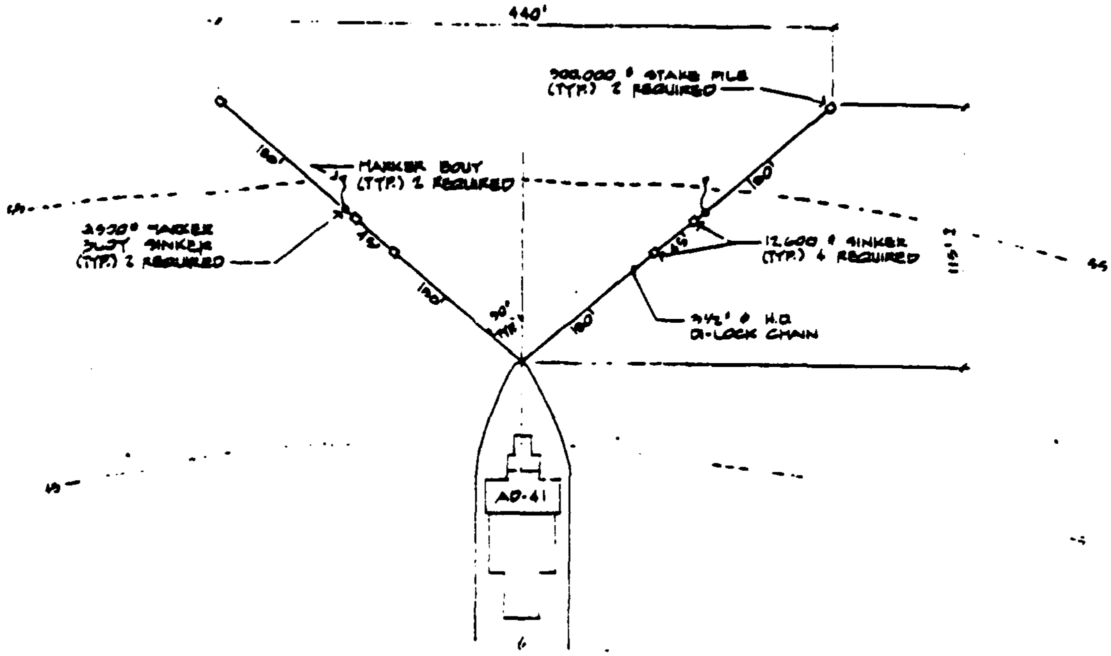
2.6 Mediterranean Moor

One recent concept considered for a floating pier design included the use of a Mediterranean moor (Med-moor) at the channel or seaward end of the pier. The requirement to berth an AD-41 class Destroyer Tender in a Med-moor (stern of the ship at the seaward end of the pier) was evaluated using two alternate concepts. One concept used a conventional spread mooring arrangement, as shown in figure 2-13, while the other used breasting/mooring dolphins, as shown in figure 2-14.

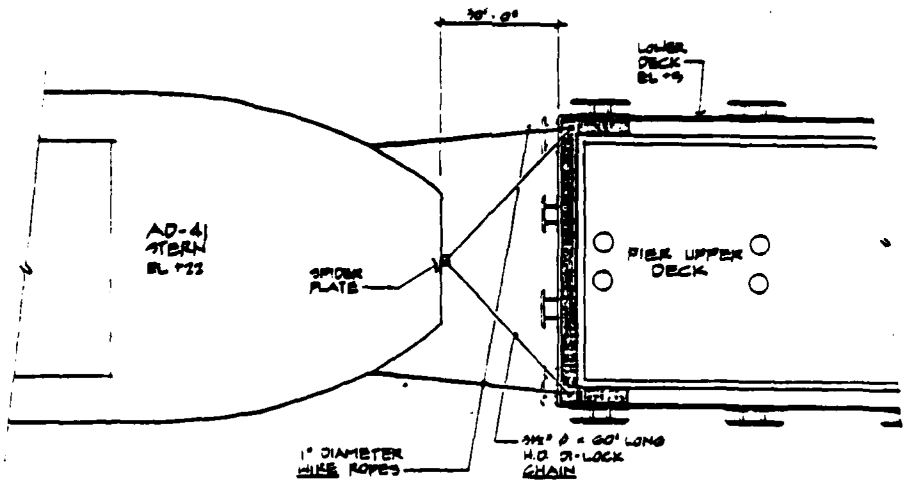
The conventional spread mooring arrangment used by the Navy typically consists of two anchor chains set from the ship's bow at an angle of about 50 degrees from the ship's projected centerline. Each of these chains terminate some 400 feet away at 300,000-pound (lb) anchor stake piles. Near the center portion of each chain, two 12,600 lb cast-iron sinkers are attached. Typically, a marker buoy is located in the area of the sinkers secured by a 6,500 lb cast-iron sinker.

A mooring system of this type uses a 3-1/2-inch bow and stern anchor chain. It was designed by providing a system of anchor chain and clump weight combination which will develop enough potential energy to absorb the kinetic energy of the Med-moored ship.

The alternate concept using breasting/mooring dolphins utilized a series of four freestanding, 72-inch diameter piles which were outfitted with floating donut fenders that remain at the destroyer tender's waterline during all tidal stages. The controlling design load for this alternative was the mooring line loading provided by a combination of wave and wind. These loadings were developed in an identical manner to those on the pier; i.e., by adding the wind load of the destroyer tender plus nested ships to the wave loading determined by finding the accelerating force. This loading was larger



BOW MEDITERRANEAN MOORING DETAIL



STERN MEDITERRANEAN MOORING DETAIL

Figure 2-13. Proposed Mediterranean Moorings, AD-41, Seaward End of Pier.

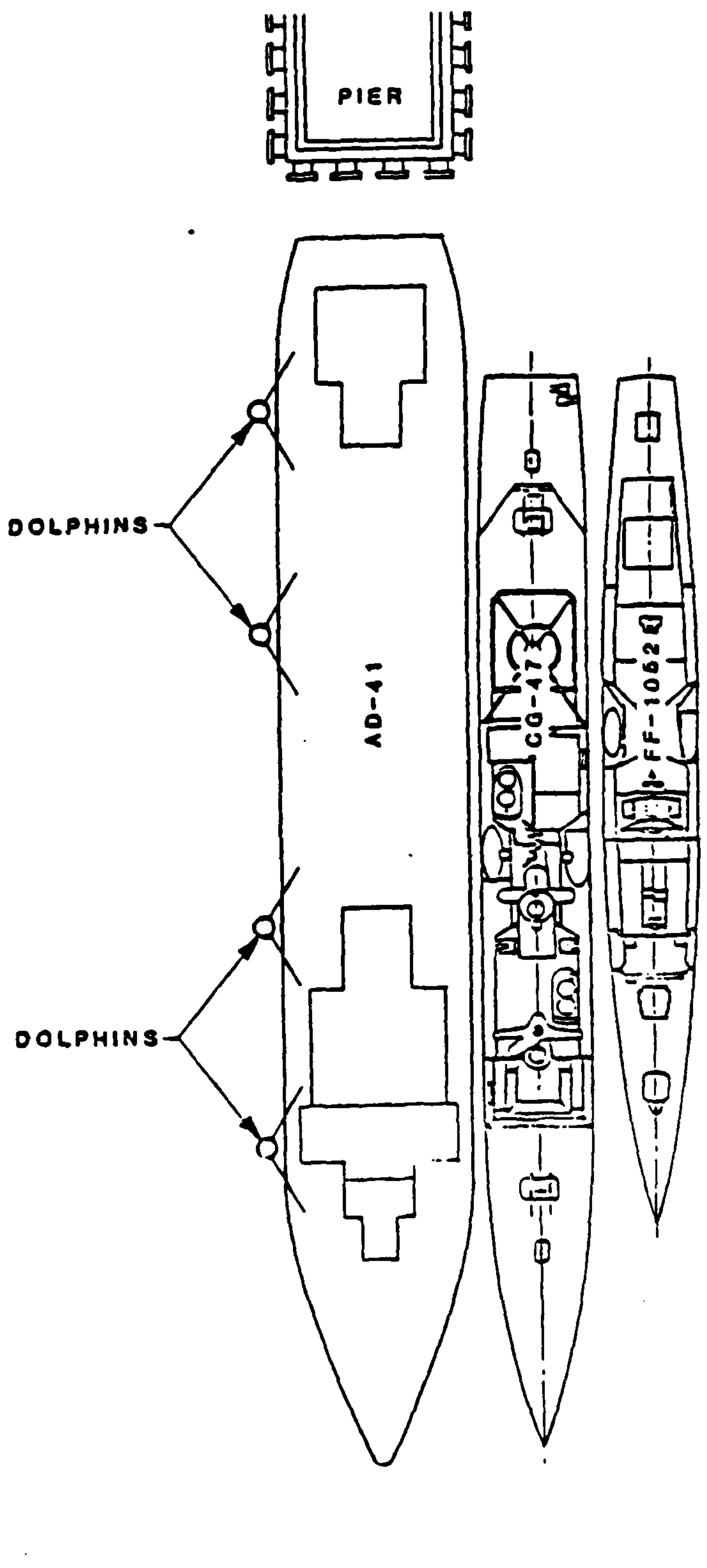


Figure 2-14. Alternate Mediterranean Moorings, AD-41, Seaward End of Pier.

than the floating fender reaction developed during berthing of the destroyer tender. Operationally, the dolphin concept is limited by the extra spacing which results if ships are nested on the dolphin side of the Mediterranean moored destroyer tender.

2.7 References.

The material contained in this section has been extracted from the following documents:

- VSE Report, Ship Data and Berthing Requirements for Small and Medium Surface Combatants, March 1983
- VSE Report, Pier Utilization Study for Small and Medium Surface Combatants, September 1983
- VSE Report, Pier Design Evaluation System, December 1983
- Brown & Root Development Inc., Report, Floating Pier Concept, Preliminary Construction and Life Cycle Cost Estimate at Pier 92, Port of Seattle, Washington, December 1983

SECTION 3

DESIGN LIVE LOAD REQUIREMENTS

The basic design live loads discussed in this section include:

- Observed crane loads occurring under current pier operations.
- Floating pier design vertical loads.
- Naval architectural considerations for a floating pier.

3.1 Main Deck Loads

3.1.1 Current Pier Operations. As a part of an NCEL pier utilization study covering support to small and medium surface combatants, investigations were conducted at two large Navy complexes to evaluate the requirements for crane services and the capabilities of piers to support these services. The items of concern were types and frequency of operations, typical weights, space and access to the ship required by cranes, and constraints imposed on crane service by current pier designs. Minor crane lifts were classified as those made in placement and removal of platforms and brows, minor cargo loading and other relatively lightweight, nondemanding lifts. Major lifts were those involving heavy and/or bulky loads, high work on antenna, and critical lifts such as a gas turbine engine replacement.

At NAVSTA San Diego, it was determined that an average of 360 mobile crane and 60 floating crane operations each month are made in support of small and medium surface combatants. Along with utility service to ships, crane service is obviously the predominant pier activity. Regardless of pier congestion and contention for space, access to the ship is obtained and constraints are overcome to provide service. The questions resolve to: What is being delayed or hampered, and what costs are added due to pier constraints? In general, required services are being provided, although average times may

be extended significantly. Serious pier constraints are overcome by extensive use of floating cranes and accepting the added cost and time.

One typical constraint on older piers is the live load restriction which limits the size of cranes. On newer piers, live load capabilities are greater but the outboard portions of the deck may be dedicated to utility systems, service outlets, and lay down areas for electrical cable and utility hoses, thereby, countering the advantages of the added capacity. The newest surface combatant pier at the site was designed to specifically exclude functions other than utilities from the area closest to the ship. Cranes must, as a result, add a 15-foot offset to reach the pier edge for practically all lifts. The result in each case is a serious reduction in the crane capacity necessitating use of oversized mobile cranes and floating cranes. Even without a physical barrier, the offsets required by reason of the utilities cables and hoses being located on the main deck, is significant. In summary:

- On piers with physical barriers, the average crane capacity was reduced by 30 to 40 percent, resulting in approximtely 40 percent of the mobile crane major lifts requiring oversized cranes due to the extended radius. Another 30 percent of the major lifts had to be made by floating cranes due to the con- straint on mobile cranes. Piers without physical barriers ex- perienced somewhat less reductions.
- Antenna type work was frequently delayed or performed by floating cranes due to either pier load limitation or height restrictions of equipment.
- An average of 24 floating crane lifts per month were a result of pier constraints precluding use of an adequate size mobile crane.

- Typical heavy lifts included a 13,000 lb communications van, a boat or a portable generator. On piers without physical barriers, typical lifts are at a 55- to 60-foot radius and a height of 40 feet, thereby, requiring a 60-ton crane. On piers with physical barriers, the offset results in a radius of 65 to 70 feet to the middle of a berthed ship. At this distance, a 70-ton crane would be required. By removing the major offsets required for utilities cables and hoses, it is estimated that crane requirements could be reduced to 35- to 40-ton capacity for these typical lifts.

The heaviest crane lift reported in support of surface combatant ships was a 35,000 to 40,000 lb gunmount, estimated at two lifts per month. All such lifts were being made with the 100-ton floating crane.

At NAVSTA Norfolk, an average of 190 mobile crane and 20 floating crane operations are performed monthly in support of small and medium surface combatants. As is the case with the first station, serious pier constraints are encountered regarding pier live load limits, available width, and interferences, frequently necessitating the use of alternate means to accomplish the mission.

Of the 20 floating crane operations per month, approximately four were a result of pier contraints precluding the use of a mobile crane. The principal problem was reported as the lack of pier width in order to allow for a 70-ton crane to be positioned without shutting down other pier operations.

A typical lift, which would necessitate a floating crane, would involve a 28,000 lb trailer with a lift radius of 45 feet and height of 25 feet.

The heaviest lift requirements to be supported at this station included:

- A 50,000 lb concrete block (10 ft x 10 ft x 10 ft), used for load tests, radius = 35 ft, height = 10 ft. Frequency averages 4 times per month.
- A 60,000 lb donut or camel, radius = 25 ft, height = 10 ft. Frequency averages 2 times per month.

A more typical heavy lift in support of a surface combatant would consist of a 3,000 lb antenna mast element with a lift radius of 55 feet and lift height of 150 feet; the frequency of requirement would average 12 times per month.

In evaluating the physical requirements of the crane lifts at each station, it was concluded that small and medium surface combatant piers with clear deck areas, should accommodate cranes up through 90-ton capacity to accomplish most of the major lift requirements. The requirements for piers with greater capacity would not appear to be supported by current operational data.

3.1.2 Floating Pier Design. The design of the floating pier, presented in this Guide, included supporting a 90-ton crane with a uniform deck loading of 600 pounds per square foot (psf). The maximum outrigger load was 187 kips. The design concept was to allow the outrigger to be placed at any location on the main deck. An alternative design concept was to provide specific corridor sections for the outriggers. The dead-weight of the main deck would be minimized with this approach but field personnel report that in practice the outriggers would not be placed only on the thickened corridors. Hence, this alternative is not recommended.

3.2 Naval Architectural Considerations, Floating Pier

The introduction of the floating pier concept into design practice requires detailed review of naval architectural considerations affecting the

flotation and stability of the system. Several elements critical to the floating pier design include:

- <u>Wave Height</u>

The maximum wave height for the pontoons while being towed in open water, was calculated by using two methods. The first was the longitudinal bending moment method for Trocoidal waves and the second was according to the American Bureau of Shipping (ABS) Rules. Once a longitudinal bending moment was calculated for a Trochidal wave of some assumed height, the allowable wave height could be calculated by proportioning. This was possible because the allowable bending moment for the pontoon section was known. The Trochoidal wave method and the ABS method gave similar results for pontoon units of 600 feet in length. The allowable wave height was 5.4 foot for the assumed wave length of 600 feet. The design procedures specify that the wave length be equal to the length of the vessel.

A pier unit built in protected water should not encounter a wave height of more than 5.4 feet. It is also unlikely that a 5.4 foot wave will be as long as 600 feet.

For pier units intended for ocean towing, it would be necessary, depending on the severity of tow conditions, to decrease the length of the pier to increase its allowable bending moment, and therefore, increase the allowable wave height. For a pier unit of length 400 feet the limiting wave height was calculated as 12.2 feet; and for a pier unit of length 300 feet, the limiting wave height was 21.7 feet.

- Pier Motion

Motion of the floating pier can be induced by the following:

- Ship-generated waves
- Wind waves created by local storms
- Berthing impact of ships
- Long period seiche

Ship generated waves are a function of ship size and speed. The expected range of wave height is about 1 to 2 feet with a wave period less than 3 seconds.

Wind generated waves do not produce a significant response in the pier for incident wave angles of greater than 30 degrees. It is only when the waves approach near broadside with a period greater than 5 to 6 seconds, that a pronounced response can be expected. These conditions are not expected at most activities.

Berthing impact of ships does not present a problem regarding pier motion. The displacements are relatively small, less than 0.75 ft under the most severe conditions, and pier accelerations are minimal. By having other vessels already berthed at the pier, the displacements and accelerations from berthing impact will be reduced to even lower values.

Long period seiche waves, encountered in enclosed or semi-enclosed bodies of water, will not produce dynamic effects on the floating pier. The resonance periods for the pier are about 11 seconds in sway and about 13 seconds in heave. The seiche periods far exceed these values; therefore, the pier is decoupled from seiche waves.

In summary, the pier is a fairly stable platform which is not responsive to ship generated waves, seiche or ship berthing impact loads. The pier also shows excellent stability in wind waves except when the waves are approaching broadside and when the wave period exceeds about 5-6 seconds.

- Damage Stability

Damage stability calculations were carried out for the 1200 foot long pier for two cases of flooding of the buoyancy chambers. One case had two adjacent cells at the end of the pier flooded, and another case had two adjacent cells on the side of the pier flooded. The maximum change in freeboard at the end was a list of 1.2 feet and trim of 0.9 feet. In this damaged condition, the pier would be able to function to its full capacity. Repairs could be made without interrupting the operational function of the pier.

Should flooding occur in one buoyancy cell, the local freeboard change would be about 4-5 inches.

- Resistance to Lateral Loads

Using the environmental conditions at NAVSTA Charleston and assuming the highest ship lateral loading factor at the pier, (one AD-41 and three DD-963 class ships as shown in figure 3-1) and worst storm condition (winds of 90 mph and 6 knot currents in the channel), the combined environmental load on the pier, assuming uniform loading, would equal 2730 kips, including 1745 kips wind load and 985 kips current force. Using 29 bents at 40 foot on-center the load per bent would be 94 kips. If the AD-41

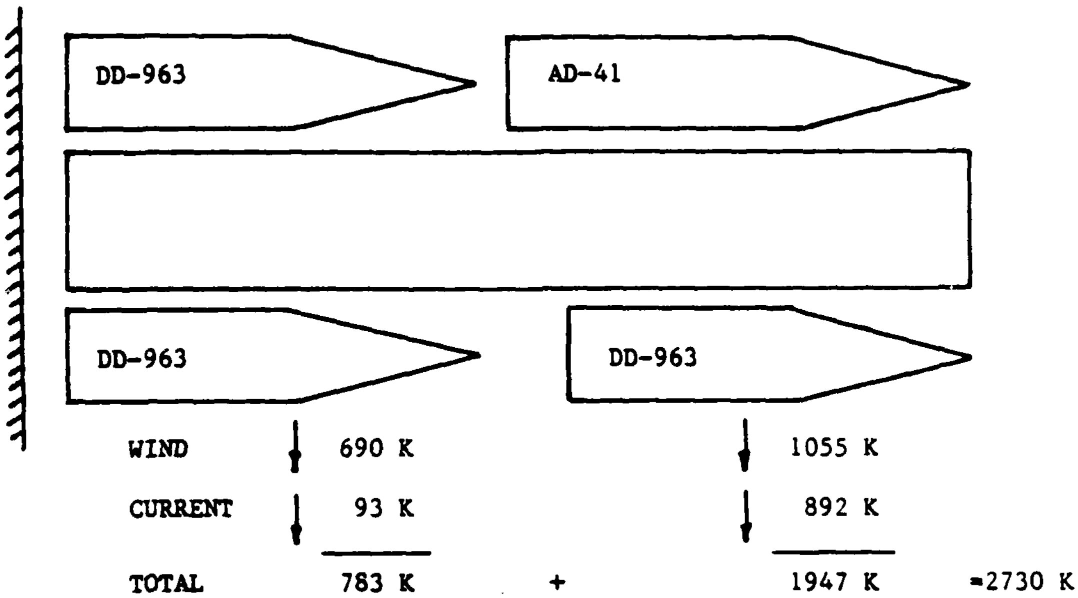


Figure 3-1. Summary of combined Wind and Current Loading.

is berthed near the channel and non-uniform loading is experienced; i.e. the lateral forces on an AD-41 and DD-963 are absorbed by only 16 bents, the worst loading condition would be 1947 kips or 125 kips per bent.

- <u>Heeling from Major Loads</u>

Heeling from two major loading conditions was analyzed. The first condition was that of two large combatant ships moored on the lee side of the pier during high wind and current conditions. The breasting lines are tied off to the bollards on the main deck, generating an overturning moment in the pier. If the mooring force was assumed as half of the maximum wind and current

load acting on 4 berthed ships, then a maximum lateral force would be experienced. For a load of 1365 kips, the resulting heel angle was 0.763 degrees, and the freeboard change was 6.0 inches. The second loading condition was that of a 90-ton crane on the edge of the main deck, making a maximum lift. The load at the edge of the main deck was estimated at 320 kips, which produced a heel angle of 0.268 degrees and freeboard change of 2.1 inches.

- Constraint

  The berthing plan used in the design was originally configured for NAVSTA Charleston, SC, and included one AD-41 and three DD-963 class ships for determining horizontal loads on piling. The design did not consider the event where four DD-963 class ships would be berthed at the pier and an AD-41 would be Med-moored at the seaward end of the pier.

3.3 References

The material contained in this section has been extracted from the following documents:

- NCEL CR 82.031, Conceptual Design of Navy Floating Pier, T.Y. Lin International, September 1982
- T.Y. Lin, Supplemental Report to Conceptual Design of Navy Floating Pier, January 1983
- VSE Report, Pier Utilization Study for Small and Medium Surface Combatants, September 1983

SECTION 4

STRUCTURAL DESIGN

Two basic structural design concepts are presented in this section:

- A double-deck, pile-supported pier design
- A floating pier design

The pier widths used in the two designs were based on operating constraints assigned at the start of the projects involving a pier width not to exceed 80 feet, and are not assumed to be standard for other operating conditions.

4.1 Double-Deck, Pile-Supported Pier

A double-deck, pile-supported pier must provide for main deck activities, utilities, galleries, vaults, traffic lanes, storage areas, parking, access to and from the pier, and piling to support the pier.

Pier Zulu, NAVSTA, Charleston SC, is the first Navy pier being constructed which employs the double-deck pier concept. Figures 4-1 through 4-5 were extracted from the Pier Zulu drawings to show the overall configuration of this double-deck pier.

4.1.1 Configuration The total length of the pier as designed was 1378.5 feet including approach slab and ramp. The actual pier length for berthing was 1244 feet, or 622 feet per berth. The pier was designed to support the following classes of ships:

CG-16, 26 and 27
CGN-36 and 38
DD-931 and 963
DDG-2, 31, 37 and 996
FF-1040 and 1052
FFG-1 and 7

Cross-sections of the pier are shown in figures 4-1 and 4-2. The main deck is 70 feet wide and the lower deck is 76 feet wide. The lower deck will

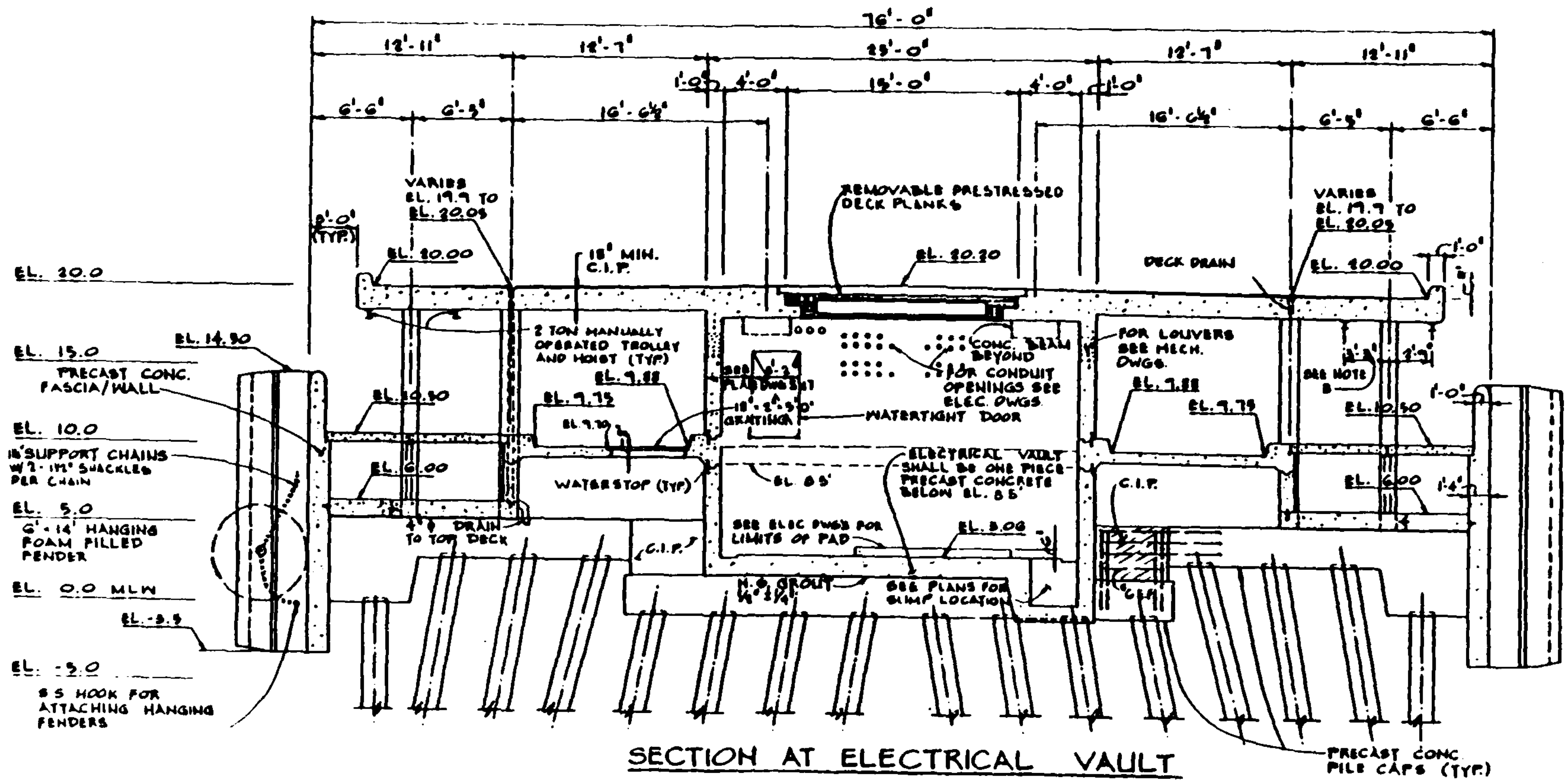


Figure 4-1. Cross Section, Pile-Supported Pier, Electrical Vault.

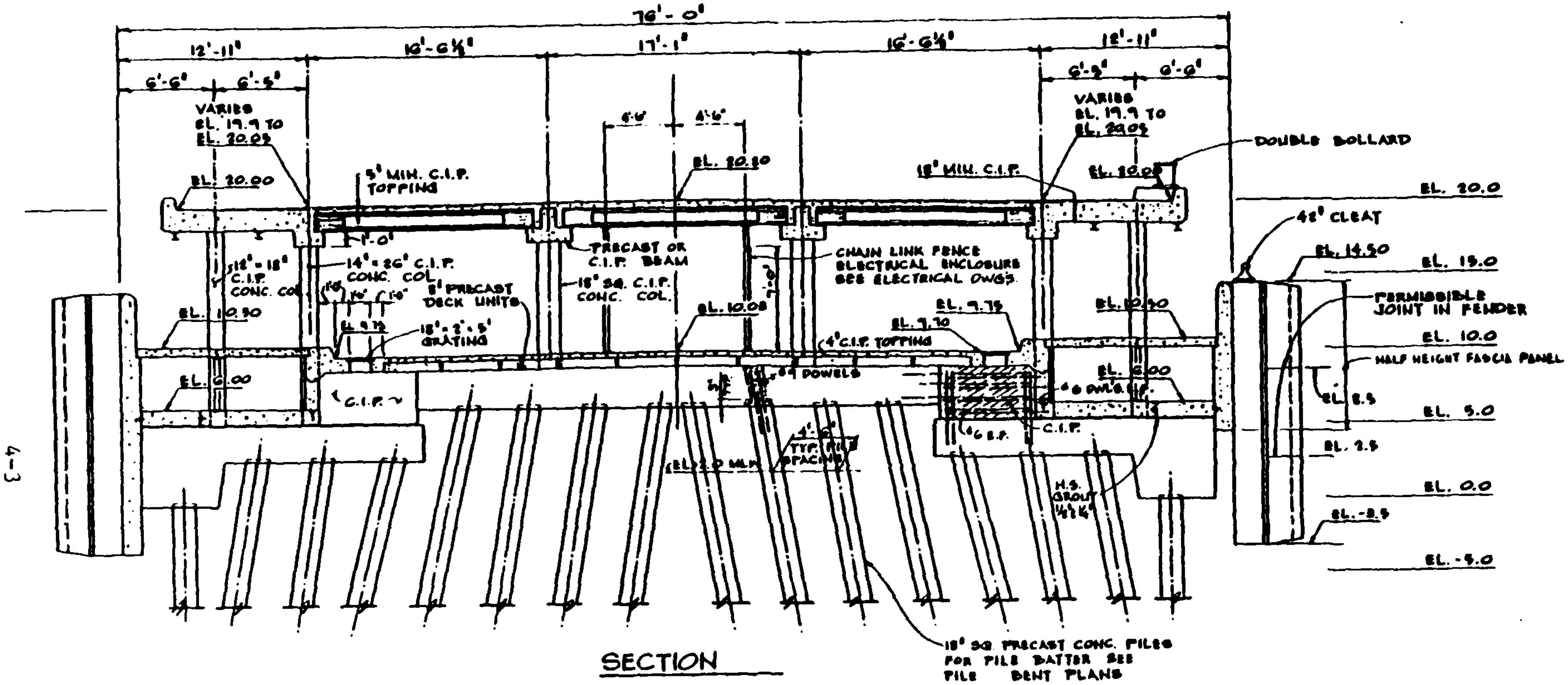


Figure 4-2. Cross Section, Pile-Supported Pier, General Area.

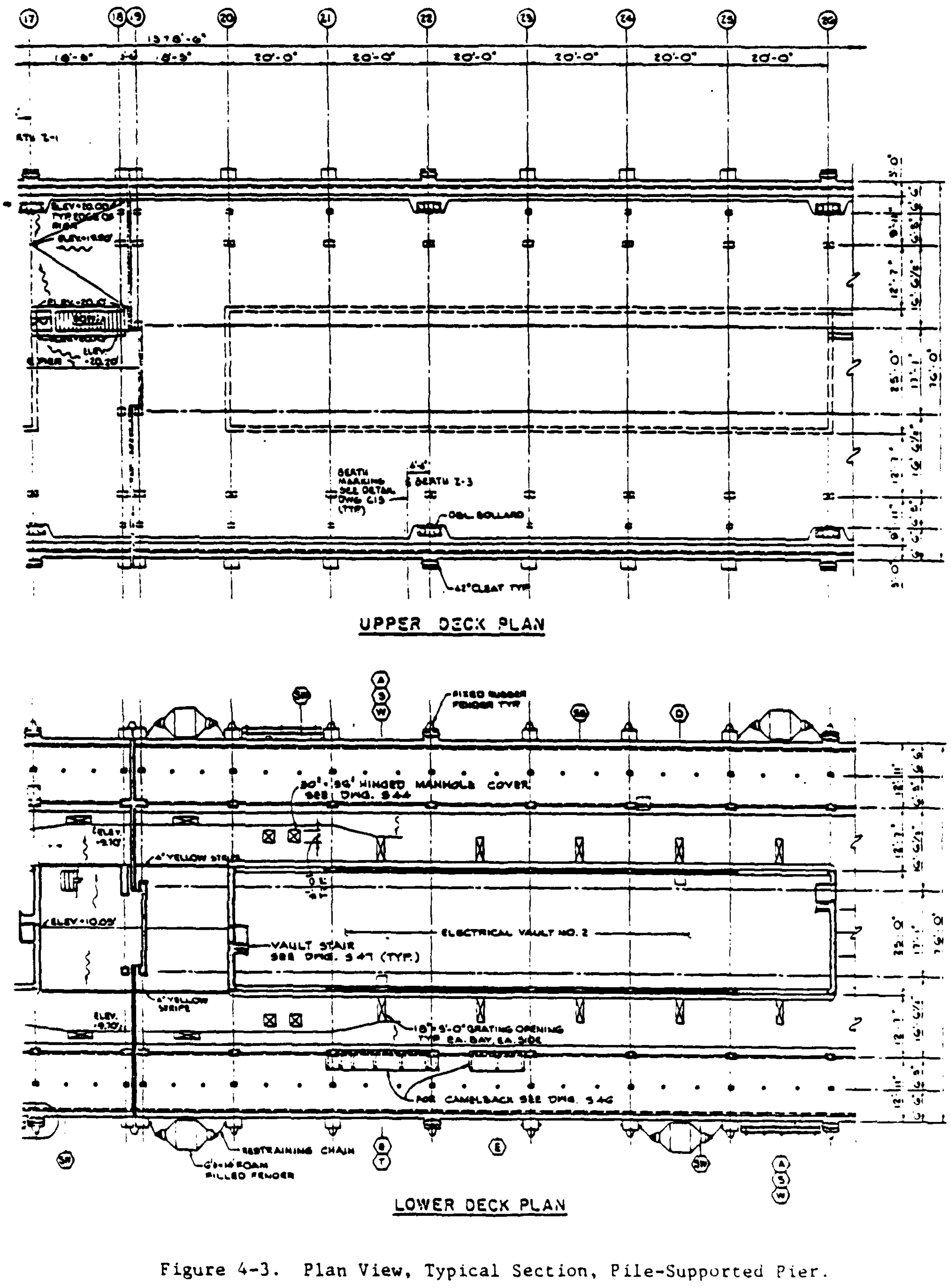


Figure 4-3. Plan View, Typical Section, Pile-Supported Pier.

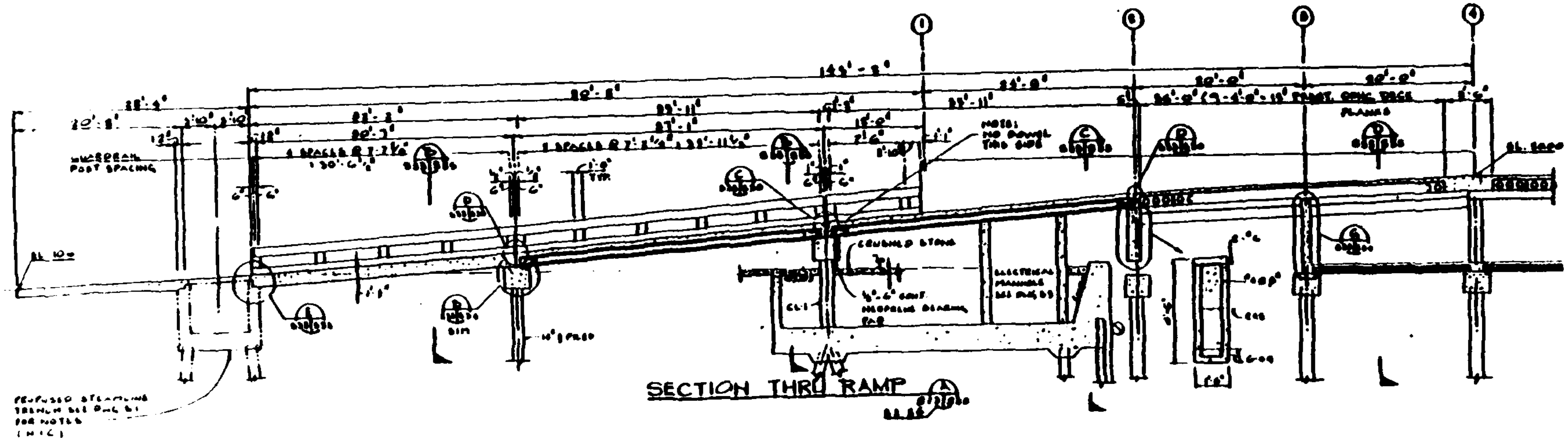


Figure 4-4. Ramp, Pile-Supported Pier.

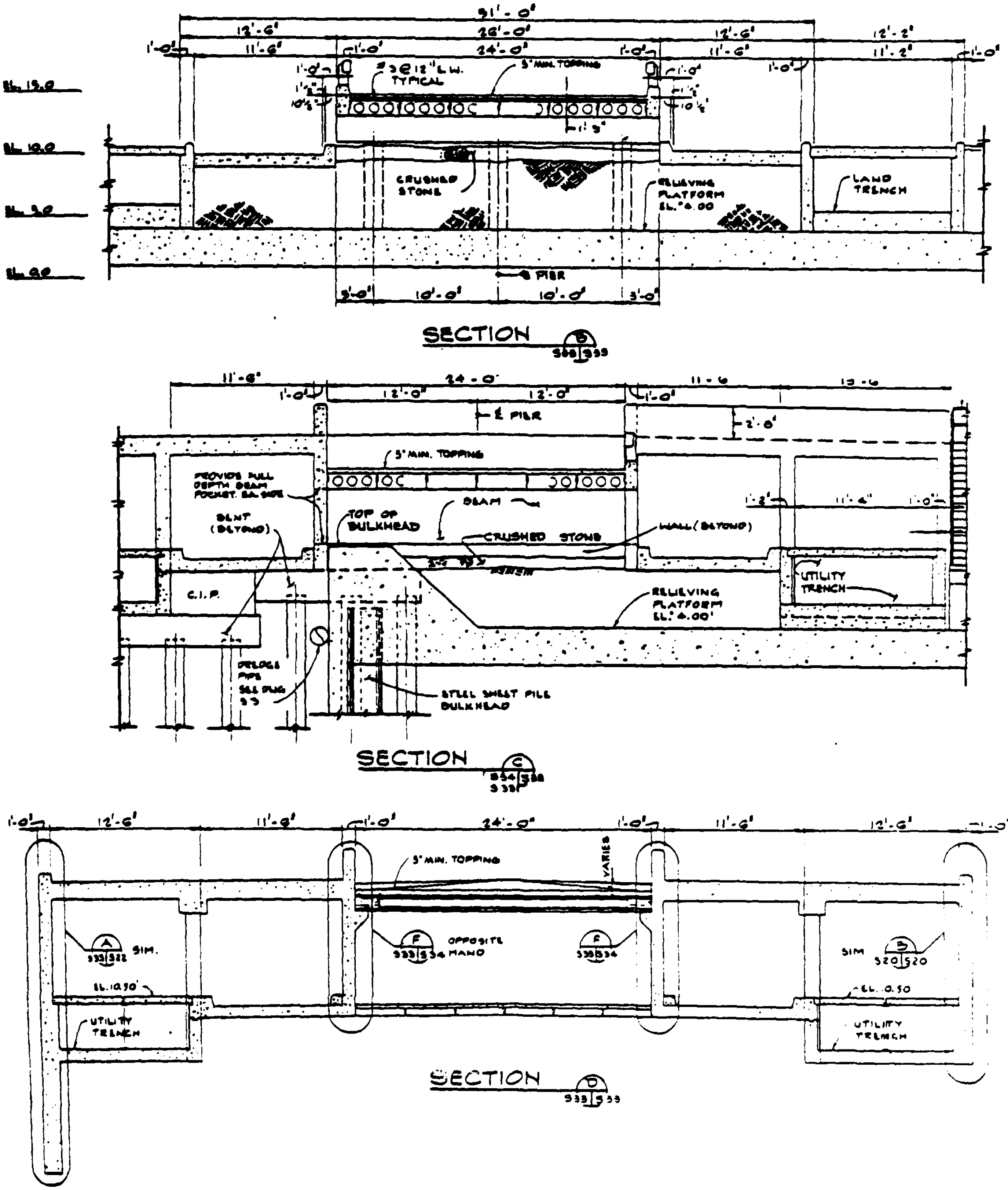


Figure 4-5. Cross Sections, Ramp, Pile-Supported Pier.

be supported at 69 bents by 3 foot wide by 2.5 foot deep pile caps supported on sixteen, 18-inch square precast concrete piles. The bents are 20 feet on-centers. The main deck is 18-inch thick concrete; 22-inch prestressed concrete deck planks covered by a 5-inch concrete topping are used over each vault. The main deck is supported at each bent by:

- Six concrete columns ranging from 12 inch x 18 inch to 14 inch x 26 inch where transformer vaults do not exist.
- Four concrete columns, either 12 inch x 18 inch or 14 inch x 26 inch and 12-inch concrete wall, where transformer vaults exist.

The main deck of the pier is intended to be a "clear" area. The lower deck is divided into three longitudinal sections; i.e. the transformer vault and distribution system in the middle of the pier, an 11-foot traffic lane on each side of the vault, and an 11.5-foot utility gallery outboard of the traffic lanes on each side of the pier. An offset of 3 feet is provided on each side of the pier between the main deck and lower deck in order to provide access from the main deck into the utility gallery.

The main deck elevation is 20.2 feet above MLW, at the center and 20 feet at the outboard sides. The lower deck elevation is 10.5 feet in the utility gallery, 10 feet in the center of the pier, and 9.75 feet at the outside curb of each traffic lane. The elevation of the pipeway in the utility gallery is 6 feet above MLW and the transformer vault is 3 feet. The vertical clear distances are approximately 7 feet 8 inches in the utility gallery and 8 feet 3 inches in the traffic lanes.

Six stairwell openings are provided in the main deck providing access to the lower deck in the middle bay.

The live vertical loads used in the design for the double-deck pier were:

- Uniform distribution of 600 psf on the upper deck and 100 psf on the lower deck, utility galleries, and transformer vaults.
- Concentrated loads were 151 kip maximum on the upper deck and 5000 lb on the lower deck, utility gallery, and transformer vaults.

4.1.2 Ramps. A 24 foot wide ramp, as shown in figures 4-4 and 4-5, is provided between the shore line and the upper deck for large load handling equipment and trucks. Sloped ramps, 11 feet wide are provided to the lower deck from the shore line.

4.2 Floating Pier

The floating pier must also provide for different levels of main deck activities, utilities, galleries, vaults, traffic lanes, storage areas, parking, access to and from the pier, and a method for anchoring the pier.

A floating pier having a main deck height of 20 feet and width of 65 feet, and an overall pier width of 75 feet at the waterline, would basically conform to the design shown in figures 4-6 through 4-16. This design was based on environmental and operational parameters existing at NAVSTA, Charleston.

4.2.1 Pier Configuration. The total length of the pier was assumed to be 1250 feet comprised of a 1200 foot long structure and a 50 foot ramp to span between the pier and shore. This length pier was marginally adequate for berthing two CG's or DD's at 564 feet long, each along one side of the pier. If an AD were berthed on one side, then the remaining space was only adequate for a Fast Frigate (FF) or Guided Missile Fast Frigate (FFG).

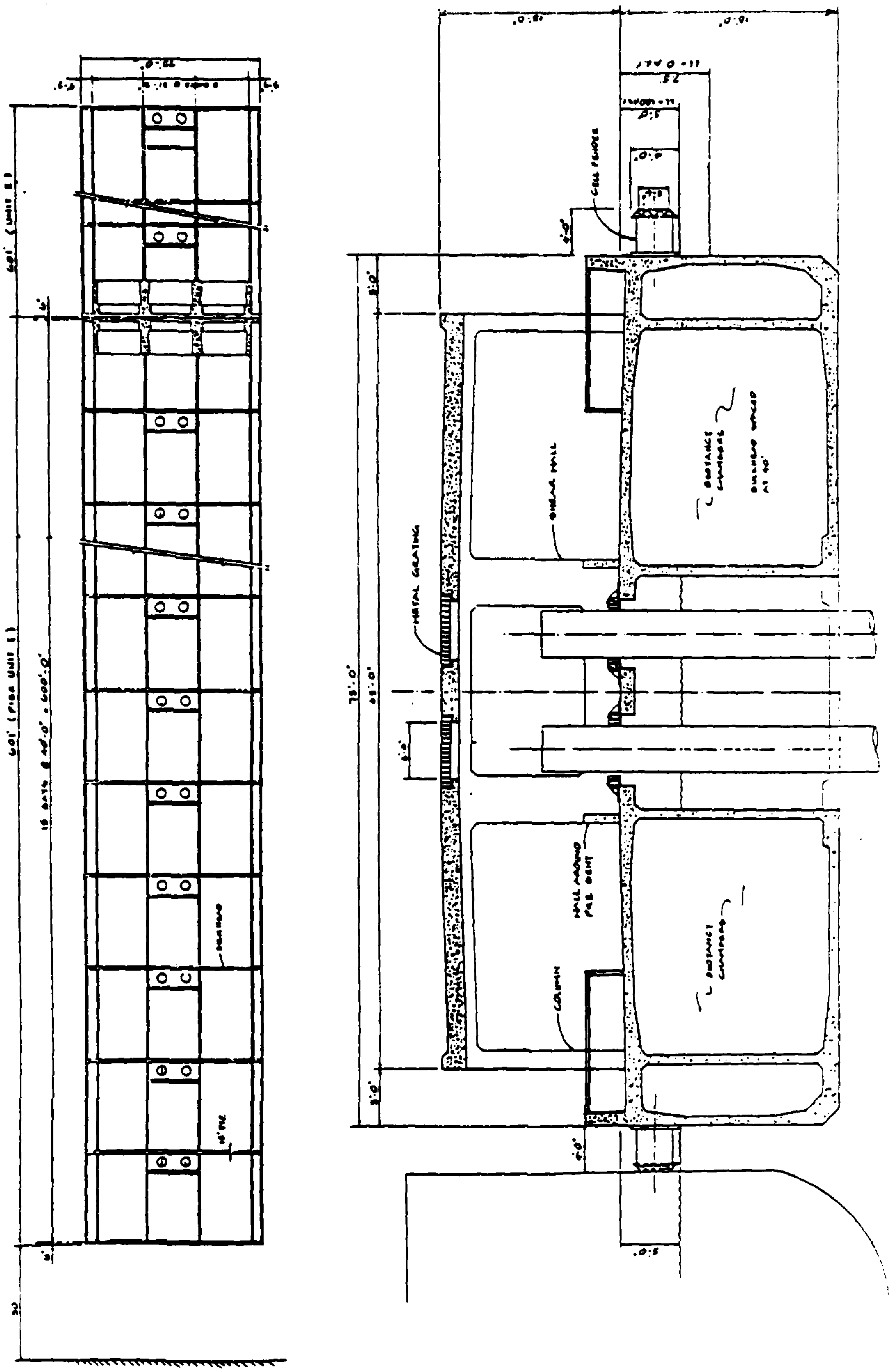


Figure 4-6. Floating Pier, Plan and Cross Section.

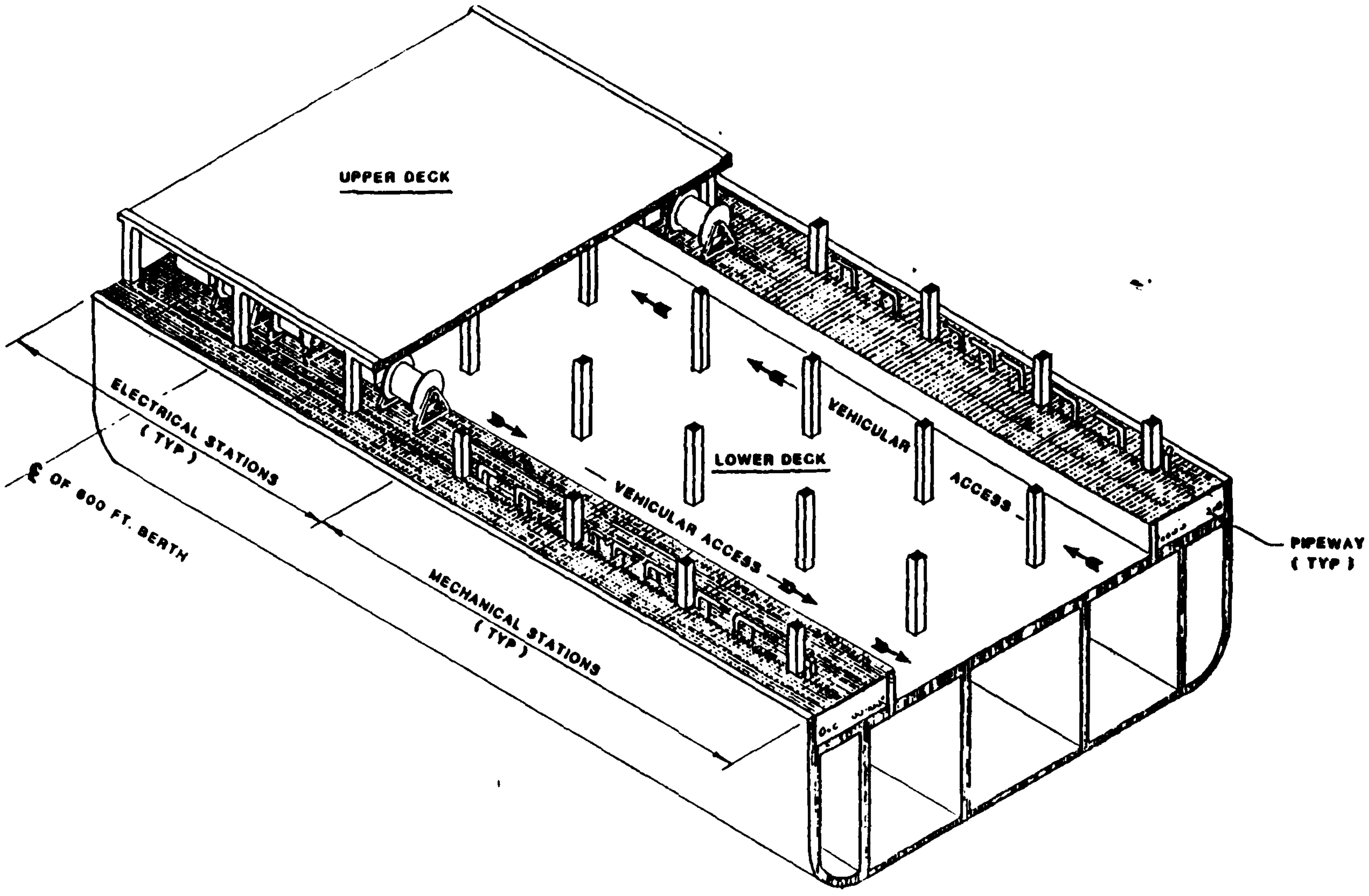


Figure 4-7. Perspective of a Section of a Floating Pier.

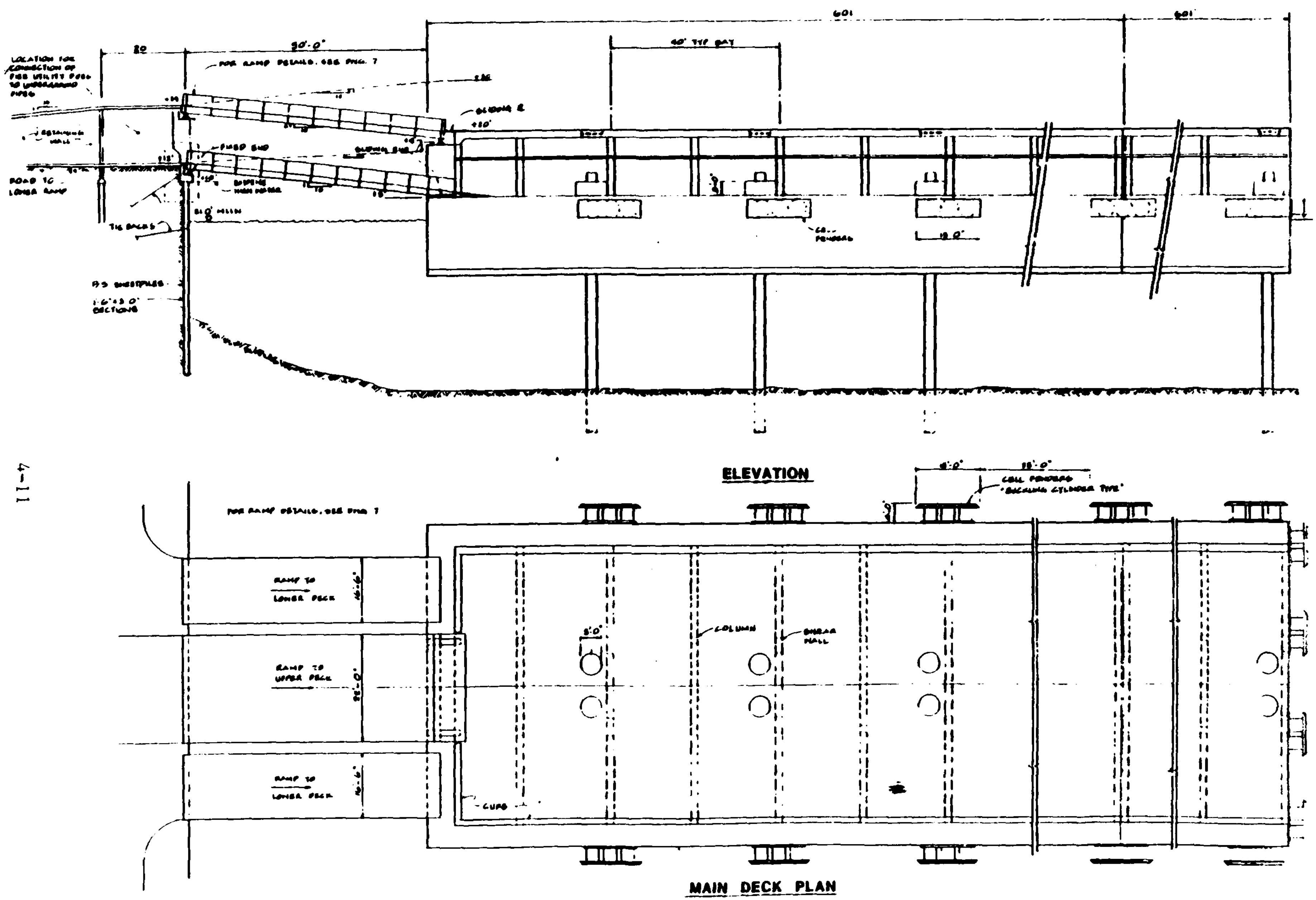


Figure 4-8. Floating Pier, Elevation and Main Deck Plan.

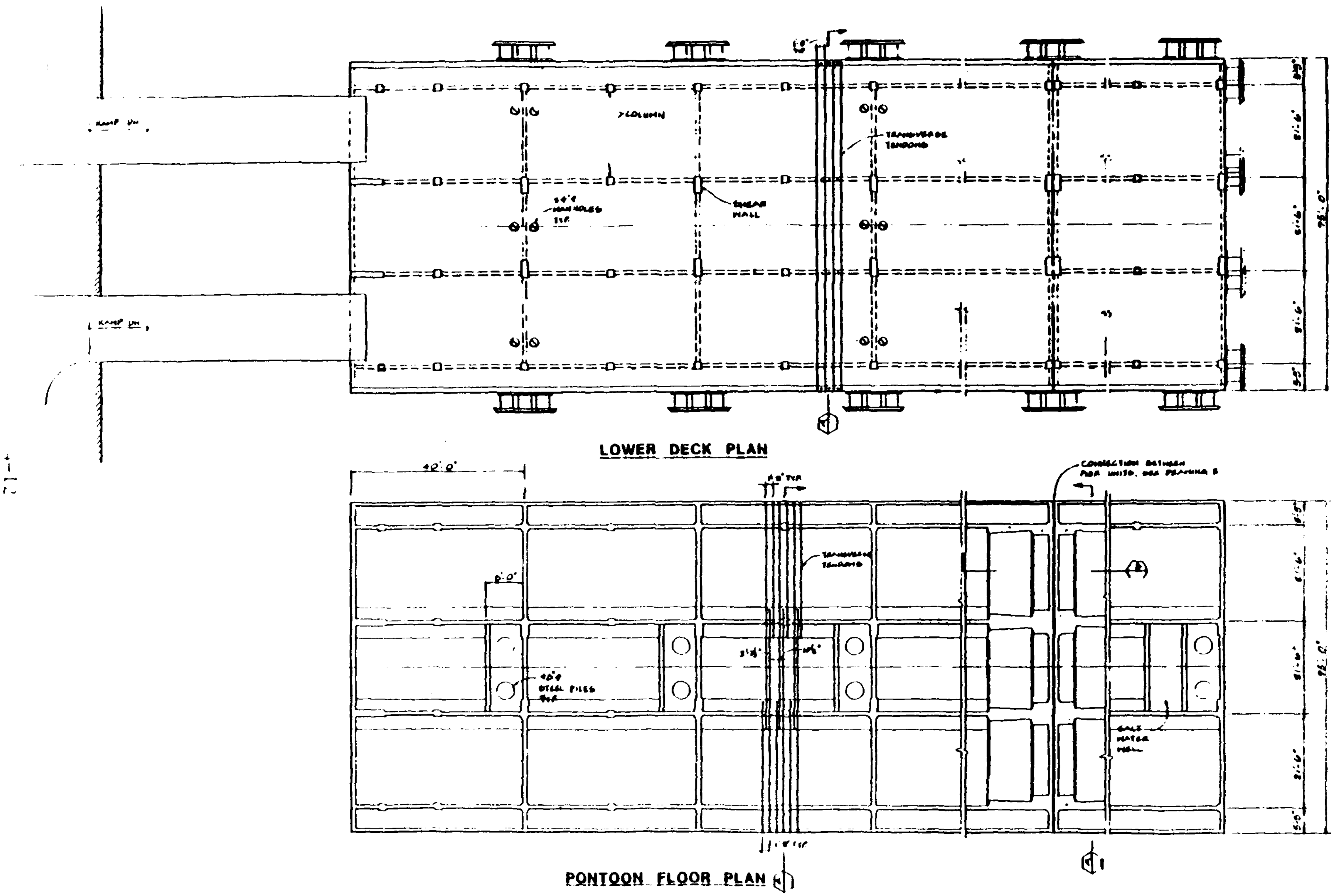


Figure 4-9. Floating Pier, Lower Deck and Pontoon Floor Plans.

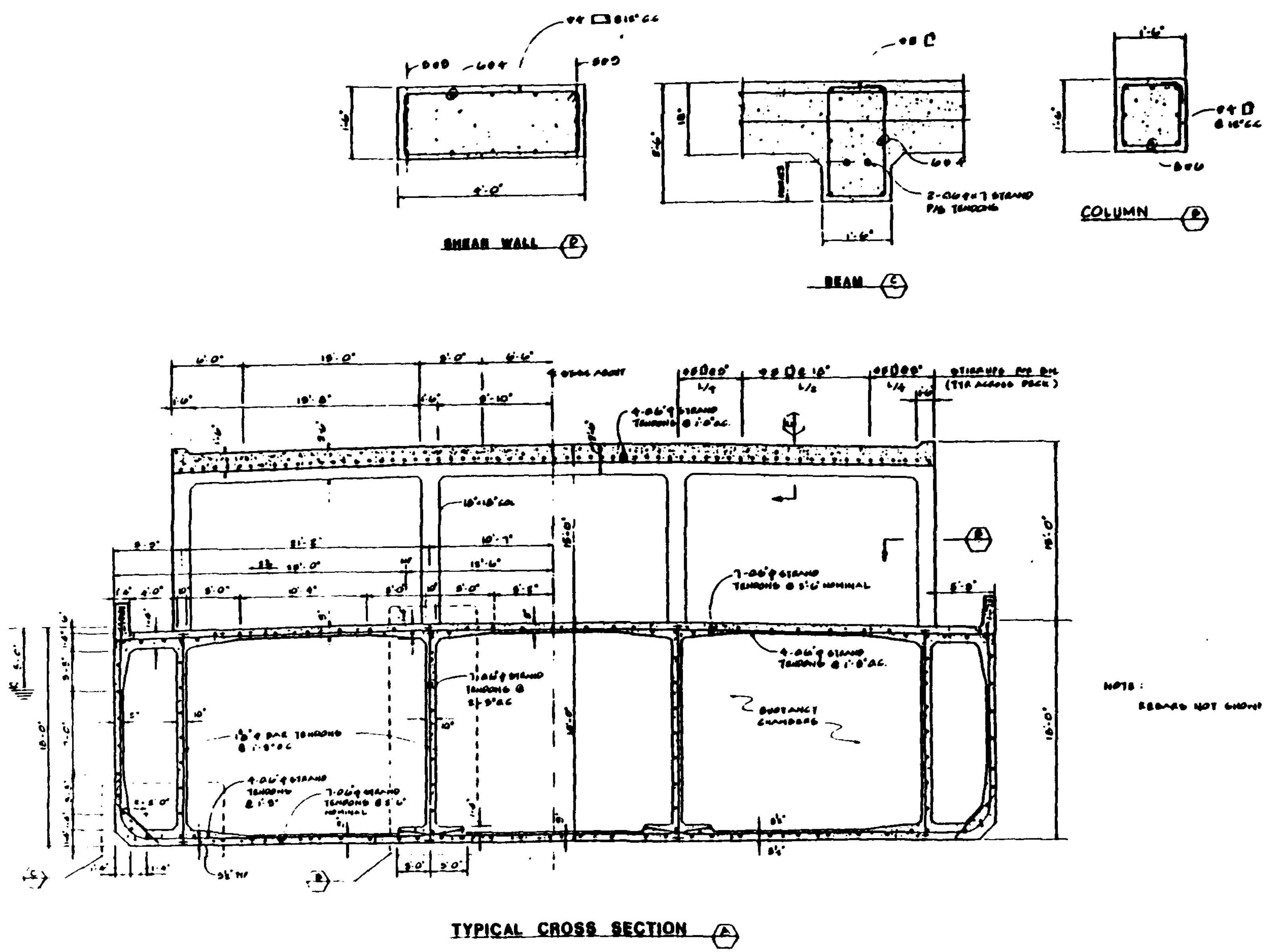


Figure 4-10. Floating Pier, Typical Cross Section.

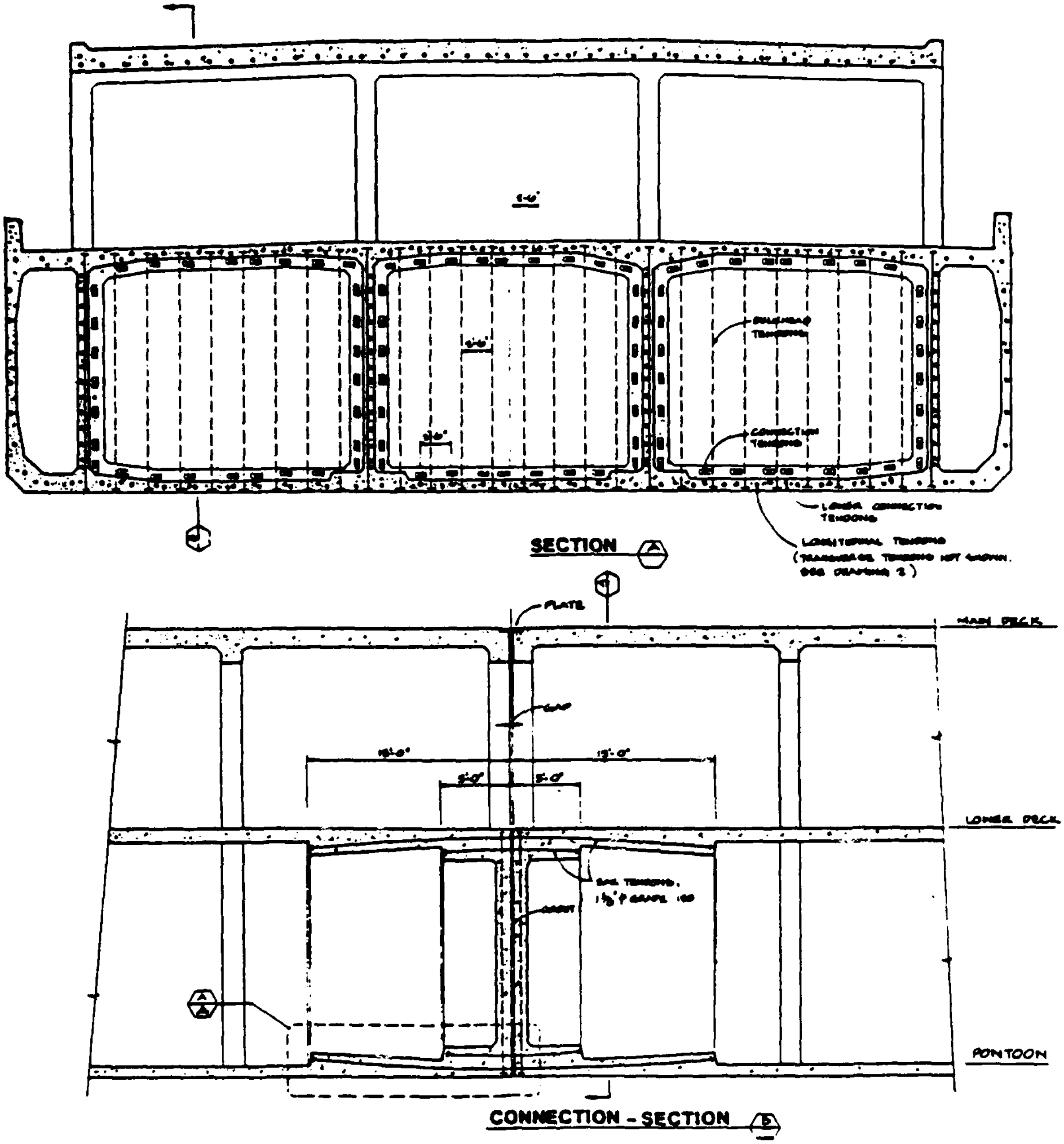


Figure 4-11. Details of Joint between Floating Pier Modules.

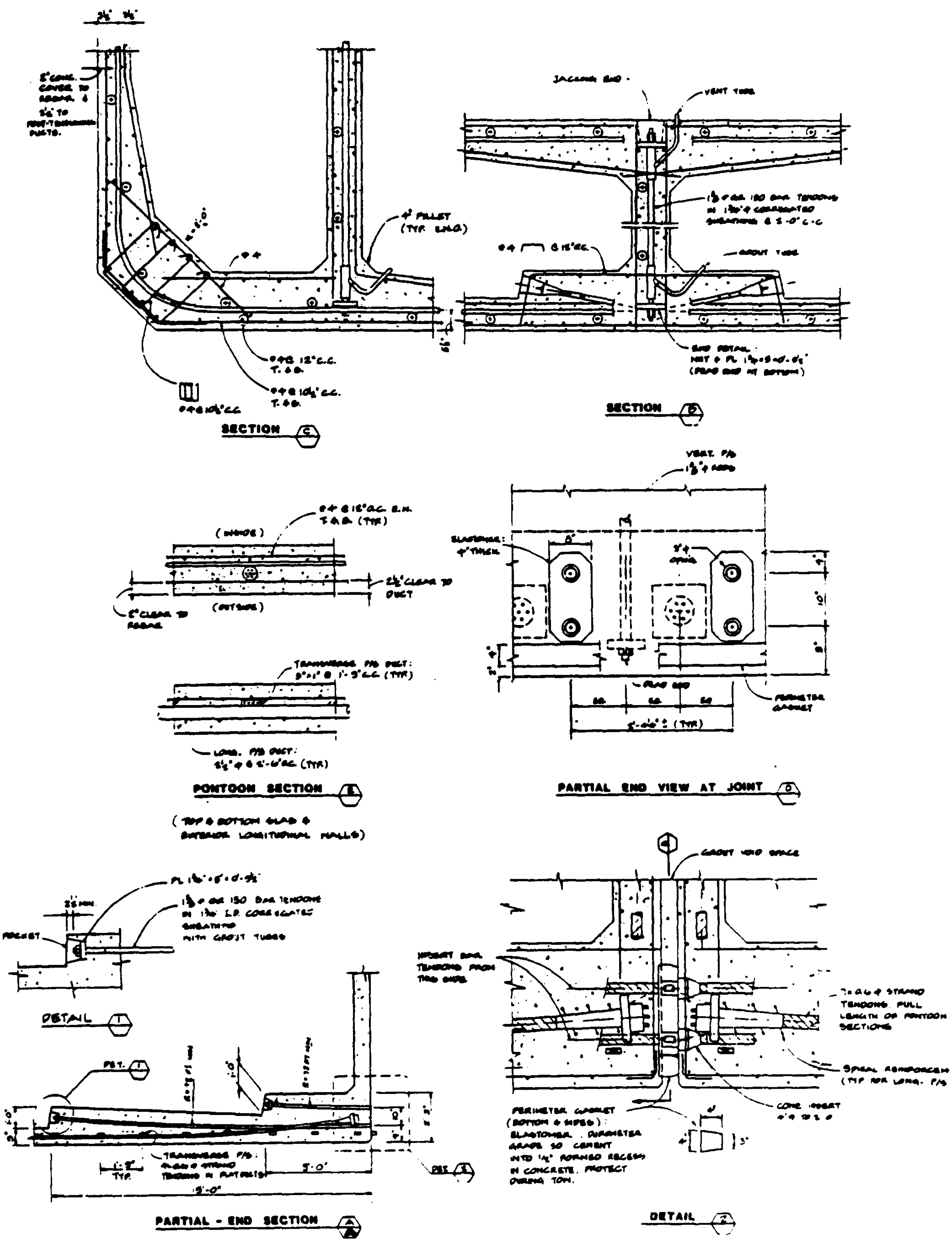


Figure 4-12. Additional Floating Pier Details.

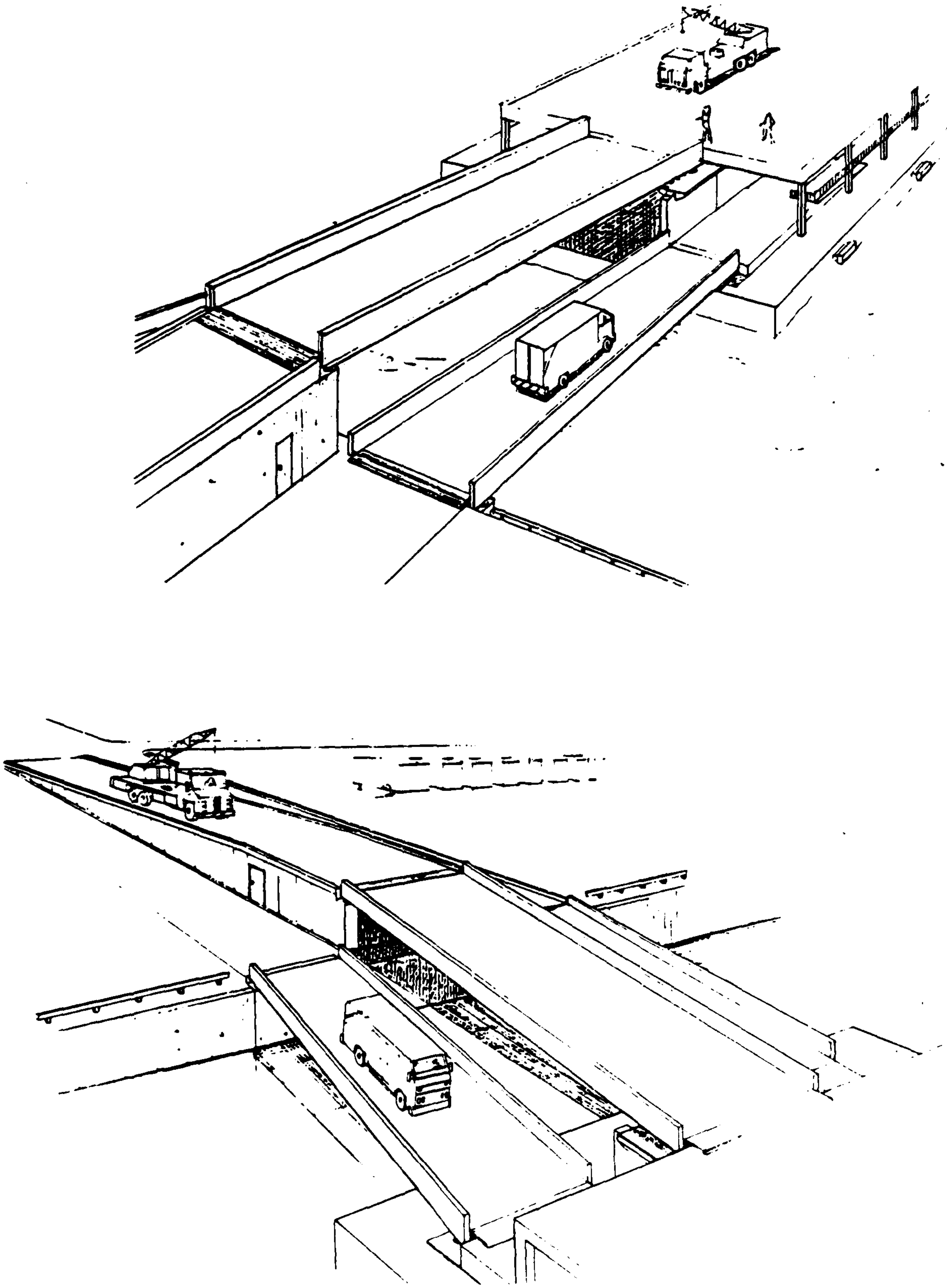


Figure 4-13. Floating Pier Ramps.

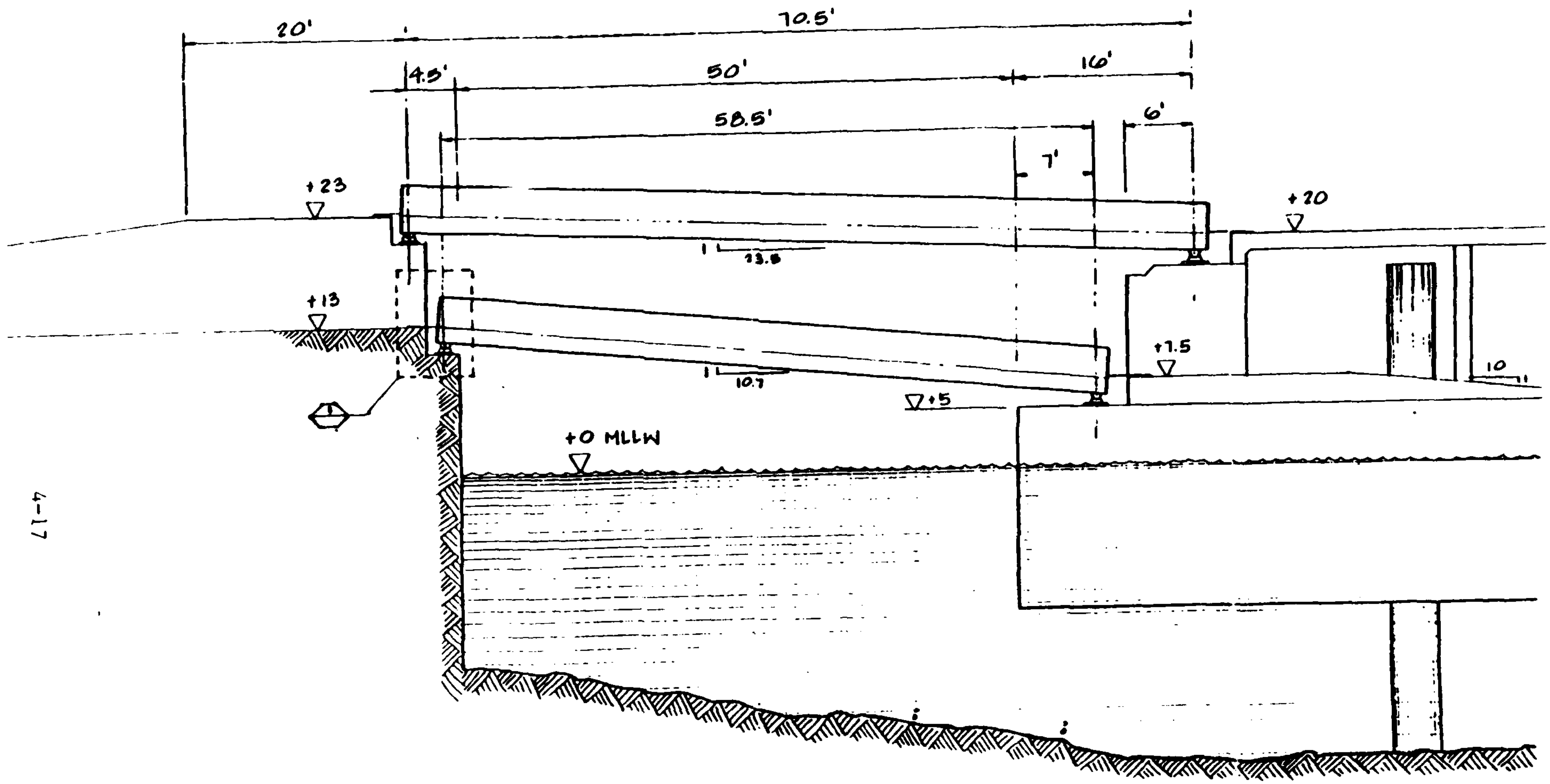


Figure 4-14. Elevation View of Floating Pier Ramps.

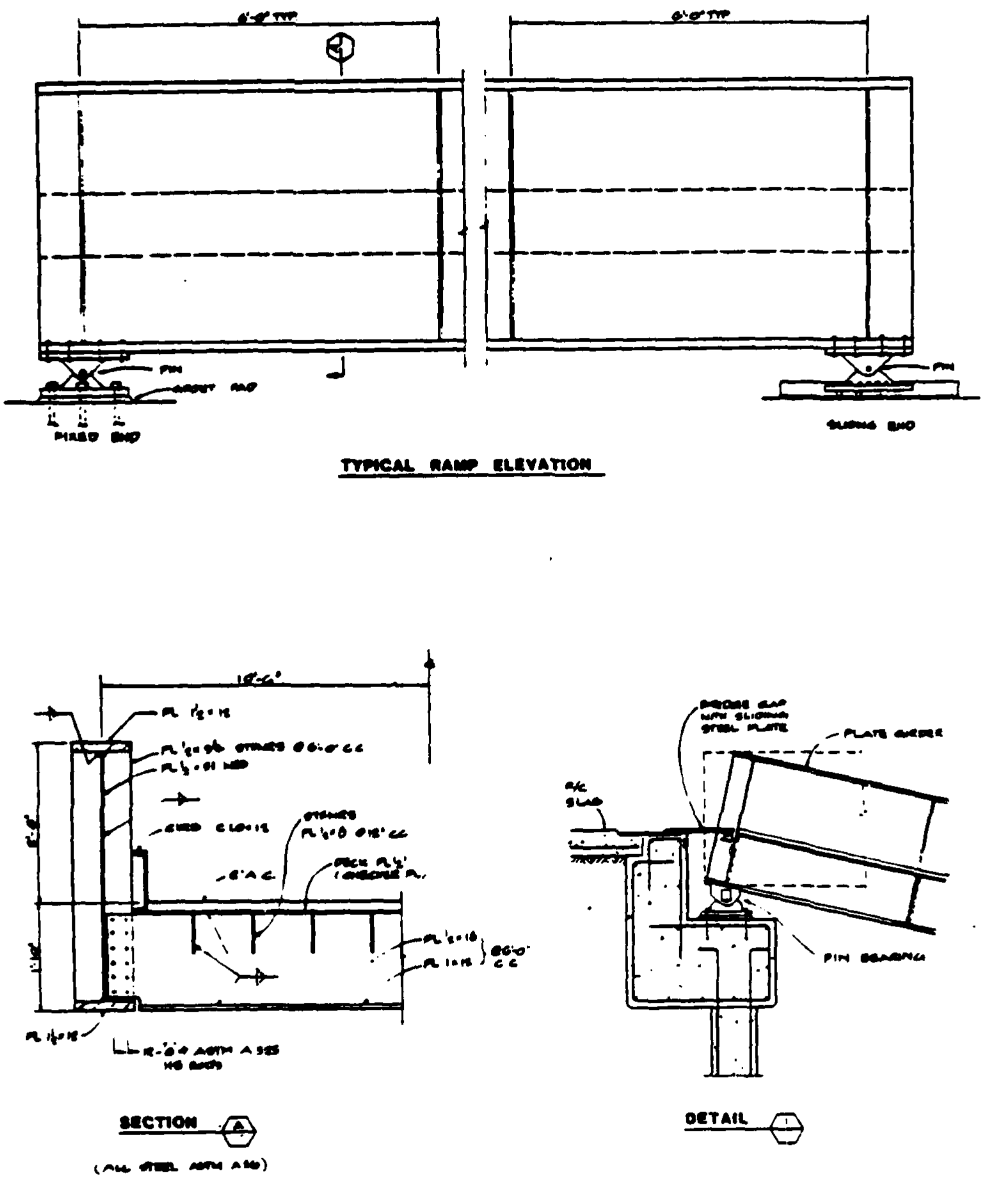


Figure 4-15. Details of Floating Pier Ramp Supports.

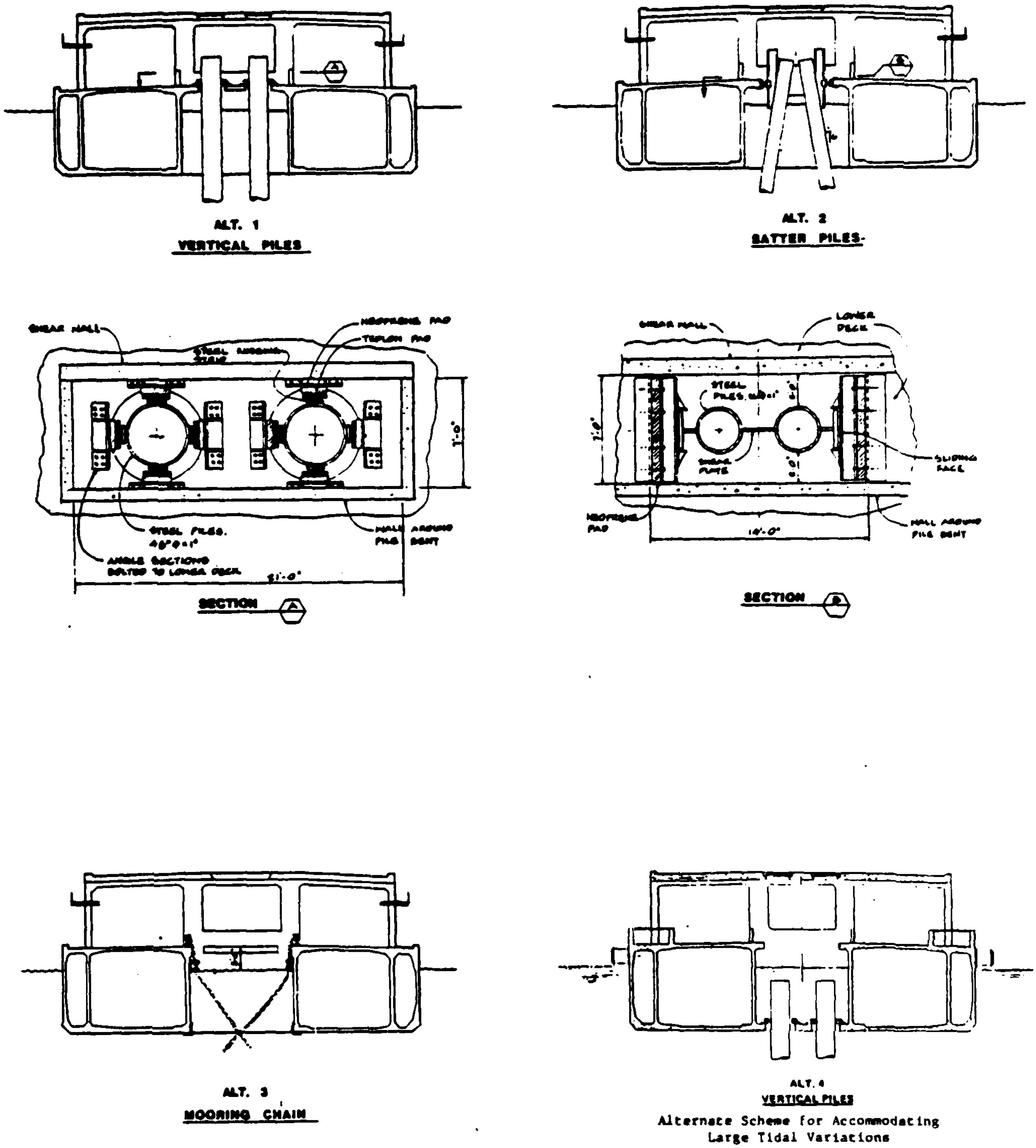


Figure 4-16. Floating Pier Anchorage Alternatives.

The preliminary design is for two 600-foot long pier units. The decision to use two pier units was to demonstrate that the pier could be built offsite in multiple units and joined together at the site. The joint design would be similar whether 2, 3, or 4 units were used to assemble the 1,200 foot length.

The cross-section of the pier, shown in figure 4-6, is a two-deck configuration. The pontoon section has dimensions of 75 feet wide by 18 feet deep. The exterior wall and bottom slab are haunched sections with a minimum thickness of 9 inches. The interior wall thickness is 10 inches. A double exterior wall is provided in the event that a ship collision could result in a breach of the outer wall. The remaining cross-section is divided into three buoyancy chambers with a width of 21 feet each. Bulkheads are spaced at 40 feet. This arrangement compartmentalizes the total pier into 90 buoyancy chambers, thereby providing high damage stability.

The roof of the pontoons serves as the lower deck. Because of longitudinal bending moment considerations from "hogging" and "sagging," the thickness of the lower deck is equal to that of the bottom slab, 9 inches. This deck is adequate to resist a uniform live load of 600 psf, and the more critical wheel loading condition from a 20-ton fork lift truck.

The main deck is located 15 feet above the lower deck and is 65 feet wide. A 5-foot set-back on each side of the pier is provided for utilities access. The thickness of the main deck is 18 inches and it is post-tensioned longitudinally to a level of about 660 psi. The controlling live load condition for this deck was the concentrated load from an outrigger of a 90-ton truck crane.

Openings in the main deck are provided for pile installation. The openings are covered with a metal grating, instead of cast-in-place concrete,

for the purpose of avoiding inadvertent placement of an outrigger on the cover. A solid cover may be deceptive insofar as the appearance is one of strength; whereas, metal grating does not appear strong enough to support an outrigger.

The main deck is essentially clear of obstacles. The center of the main deck is assigned as a 24-foot wide fire lane providing two way traffic flow on the pier. On each side of the fire lane are the berthing support areas, measuring approximately 600 feet long and 20 feet wide, dedicated to providing support to the ship housekeeping, maintenance and repair, and outfitting functions.

On the lower deck, columns divide the deck into three longitudinal bays each having a clear width of 19.5 feet. The center bay is interrupted by pile bents every 40 feet; however, usable center bay space is about 20,000 ft^2 including transformer vaults and saltwater pumping station. The unused space is available for small vehicle parking, material and equipment storage, and expansion of the utility systems.

The two outside bays serve as traffic lanes and utility galleries. One-way traffic lanes 11 feet wide are provided near the inside column line. Between the traffic lane and the outside edge of the pontoon is a space about 14.5 feet which provides a complete utility gallery with pipeway, power reels, electrical mounds and hose storage area. See section 6 for a discussion of the utility gallery.

Combining the width of the lower and main decks gives a total effective pier width of 140 ft. This amounts to a pier surface area of approximately 3.8 acres. The actual overall narrow width of only 75 feet is a desirable feature, especially for piers at locations with limited waterfront area. In comparison, a large single-deck pier typically has a width of 120 feet.

The floating pier provides 15% more deck space while occupying 60% less water space. Figures 4-6 through 4-16 provide perspective, plan views, elevations and details of a 75-foot wide floating pier.

The pontoon was designed with a uniform prestress level of 750 psi compression in the longitudinal, transverse, and vertical directions of the pier. Prestress level across the joint was also 750 psi. Details of the prestress system are shown in figures 4-10 through 4-12.

4.2.2 Ramps. A ramp system is provided with a 20-foot wide roadway to the main deck for large load handling equipment and trucks. Smaller ramps having a width of 15 feet are provided for access to the lower decks. Actual lane width would be 11 feet. The ramp arrangement was designed to have a maximum slope of 1 to 10 for extreme high and low water levels. To accommodate grade limitations, an elevated roadway on the shore side was required with a maximum elevation of 12 feet above ground level. This elevated road provides a cellular abutment room for the pier utility pipes to connect to an underground supply system.

The ramps are pinned at the shoreside end and slide on the pier end. A horizontal sliding surface of 3 feet for longitudinal movement is provided on the pier end to accommodate extreme displacement. The ramps have through-girders with an open-rib orthotropic deck. It is important that the ramps do not fall off the pier because of their critical function. The pier may survive a major earthquake but it can function at maximum capacity only if the ramps are not disabled. At certain harbors, for example San Diego, shoreside space is not available for an elevated approach roadway. In this case, an alternate design would provide longer ramps so that tidal variations do not produce excessive grades.

Figures 4-13 and 4-14 show a typical ramp system for a 75-foot wide floating pier. Figure 4-15 shows ramp details.

4.2.3 Anchoring System. Three methods are available for anchoring the pier: vertical piles, batter piles, and mooring chain, as shown in figure 4-16. Each pile bent must resist the horizontal design load of 125 kips. In general, vertical piles are recommended for a floating pier. Vertical piles have the advantages of simple installation and allowing large displacement under load. They act in bending only while batter piles act in bending and axial compression or tension. Batter piles use steel more efficiently, so they are lighter in weight than vertical piles. However, this advantage is offset somewhat by their rigidity, which may be translated into the need for a more efficient fendering system. The batter piles will also require more field installation work. Mooring chains with dead-weight concrete anchors or stake piles can be used for difficult site conditions due to poor soils, deep water or large tidal variations.

Fifty-eight vertical piles, 48 inch diameter by 1 inch wall thickness, are required to meet the site specific environmental and operational conditions at Charleston, South Carolina. The piles will be filled with sand to increase their local buckling resistance and to provide corrosion resistance to the interior surface. The exterior of the piles will be epoxy coated before the piles are installed. Cathodic protection will be used for the underwater portion of the piles. A quarter-inch thickness was alloted for corrosion over the 40 year design life. This sacrificial thickness equates to a corrosion rate of 6 mils per year. The protection systems should hold the corrosion rate to less than 3 mils per year.

The pile bearing assembly at the pier-pile interface consists of steel angle sections bolted to the pontoon that rub on steel strips welded to the

piles. The angle sections have replaceable teflon pads for the contact face and neoprene blocks to absorb impact forces. The bolts anchoring the angle section to the pontoon are designed to fail in shear during overload situations instead of having the piles buckle.

The location of the pile bearing assemblies within the pontoon structure may change depending upon the site specific tidal conditions. In areas where variances between extreme high water and extreme low water vary by more than the vertical spacing between the pile bearing assemblies and the main deck, provisions must be made to accommodate the pile. This can be done by providing an opening in the main deck for the pile to protude through during periods of extreme low water, or shortening the pile and locating the bracing at a lower elevation in the floating pier structure in order to support the pile during periods of extreme high water. See figure 4-16. Leaving openings in the main deck would drastically reduce operational efficiency of the pier and is not recommended.

Moving the pile bearing assemblies from the upper deck of the pontoon (the lower deck of the structure) to the lower deck of the pontoon (the bottom slab of the floating pier) should not present any major structural problems since a transverse diaphragm is located adjacent to each pile bent. At most, it appears that localized strengthening of the diaphragm should be all that is required. This relocation does place the assembly below water. Maintenance inspection can be conducted by divers approaching the assemblies from both above and below the units.

If batter piles are used, 58 piles of 36 inch diameter by 1 inch wall thickness are required. The piles are joined together at the top by a shear plate. I-beam sections welded to the nonvertical piles provide a vertical rubbing surface. The batter piles are filled with mass concrete to increase

their dead-weight and assist in uplift resistance. Good soil conditions are required for batter piles because of the uplift forces.

Should damage occur to piles from any source, a convenient system is provided for pile replacement. The top deck has openings directly above the piles. The openings are covered by metal gratings. The gratings can be removed to provide access to the piles.

One of the advantages of locating the piles along the center of the pier is the avoidance of accidental contact between the piles and ship's sonar dome and other shipboard protrusions, which occasionally occurs in conventional piers with wooden fender piles. The expense of repairing damage to a sonar dome is high because the ship must be drydocked.

4.2.4 Materials of Construction. Concrete designs for the floating pier should consider the following:

- Normal Weight Concrete

  The key to concrete durability is to obtain a pore size in the cement paste below a critical diameter of about 0.1 micrometer. Pores of this size and smaller restrict movement of water molecules to the point that the concrete is essentially watertight. Without movement of water within the concrete, deterioration cannot occur from sulfate attack or from corrosion of reinforcing steel.

  A concrete mix design which uses a minimum cement content of 700 pounds per cubic yard and a maximum water-to-cement ratio of 0.4 will assure low permeability. A mix of this design can be difficult to place because of its low slump. The use of superplasticizers is recommended to improve workability and to avoid

the temptation to add water to the concrete in the field. Superplasticizers produce high slumps with water-to-cement ratios as low as 0.33. The recent Hood Canal Bridge construction uses this approach. Extra attention is required, however, because superplasticized concrete loses its high slump within 30 minutes after mixing.

- Lightweight Concrete

Lightweight concrete should be considered for the floating pier for two important reasons: (1) to reduce the draft of the structure, which can be important during the construction phase, and (2) to improve the durability of concrete exposed to a marine environment. Past experience has shown that the performance of lightweight concrete in a marine environment is excellent. The WW I lightweight concrete ship USS "Selma" is a case in point. The ship was scuttled in 1922 in tidal waters off Galveston, Texas. When examined 31 and 60 years later, the concrete and the reinforcing steel were found to be in excellent condition in spite of a cover no greater than 5/8 inch.

Lightweight concrete can have a compressive strength of 5000 psi and greater, using a cement content of over 700 lb per cubic yard, and presaturated lightweight aggregates. This mix will have a higher slump than normal weight concrete for a water cement ratio of 0.4. The purpose of presoaking the aggregates is to assure that water is present for a high state of cement hydration. As cement paste hydrates, it expands in volume and fills much of the void volume originally occupied by free water.

For a water-to-cement ratio of 0.4, the hydrated cement can fill enough volume to bring the average pore size down to 0.1 micrometers. Good quality lightweight concrete has the same watertightness as that exhibited by quality normalweight concrete. This has been demonstrated on concrete spheres with wall thickness of 3 inches subjected to external pressure heads of up to 4,500 feet. Pressure tests on the lightweight aggregate alone showed that the pore volume was quickly filled with seawater; hence, the watertightness of the lightweight concrete was obtained by the cement paste surrounding the aggregates. Watertightness provides protection to the reinforcing steel and prevents corrosion because sufficient quantities of chloride ions cannot work their way into the concrete to depassivate the high pH environment of the cement surrounding the steel reinforcing bars.

There is another feature of lightweight concrete that makes it superior to normal weight concrete. Lightweight aggregates are manufactured from expanded shale or clay and, therefore, contain pozzolanic materials. These pozzolans combine with the chemical compounds of the hydrated cement to form an interlocking bond at the interface of the aggregate to cement paste. Under extreme loading conditions, lightweight concrete, therefore, responds more as a homogeneous material than does normal weight concrete. The modulus of elasticity of lightweight aggregate is close to that of the cement paste, and the bond between the two materials is strong. For normal weight concrete, the bond between the cement paste and the high modulus aggregate is the

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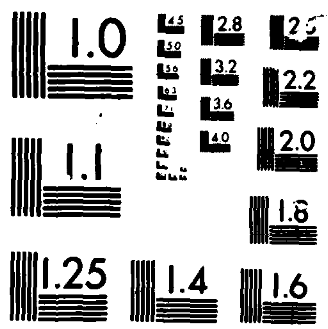


MICROCOPY CHART

location of microcrack development because of the dissimilarity in properties between the two materials. With microcracking, the watertightness of normal weight concrete is reduced.

The disadvantages of lightweight concrete are that its impact and abrasion resistance and shear strength are typically less than that of normal weight concrete. The cost for lightweight concrete is also about 50% greater than that for normal weight concrete. However, less lightweight concrete is used in the pontoon sections because the required buoyancy is provided by a barge-shaped hull of smaller dimensions. With less concrete used, less prestressing steel is required, so the higher material costs are offset by savings from using less materials.

The fatigue behavior of lightweight concrete is similar to that of normal weight concrete and is not considered to be of concern for the floating pier. A guideline on fatigue design is to maintain the stresses in the concrete below 50% of ultimate strength. This criterion is easily met for the floating pier.

4.3 References

The material contained in this section has been extracted from the following documents:

- NCEL CR 82-031, Conceptual Design of Navy Floating Pier, T.Y. Lin International, September 1982
- Gee & Jenson, Concept Study for Berthing Pier (MILCON Project P-135) Naval Station, Charleston, S.C., September 1982
- Gee & Jenson, Plans and Specifications, Berthing Pier (MILCON Project P-135), Naval Station, Charleston, S.C., 7 November 1983

SECTION 5

FENDER SYSTEMS

This section augments section 5 of DM-25.1 and discusses the direction being taken in retrofit of existing piers, recent new pier designs, and NCEL in development, test and evaluation of fenders. In addition to hardware development, NCEL is reviewing design procedures and criteria in an effort to establish berthing energy formulas that will result in fender systems capable of withstanding the berthing forces applied. The overall goal is to provide fender systems with life cycle costs at least 50% less than fender systems in use.

5.1 General

Three emphases in fender design and procurement are: (1) the necessity to protect certain critical external ship protrusions such as air masker bands, "soft" sonar domes, and stabilizer fins, (2) elimination of excessive maintenance and repair costs as typified by constant replacement of timber fender piles and major special project funding to replace conventional systems every few years, and (3) ensuring that the permissible ship hull pressures are not exceeded. Accordingly, the thrust is toward more resilient fender systems including widespread use of cylindrical, foam-filled floating fenders.

5.2 Design Considerations

Protection of the ship is the primary consideration. The following discuss two aspects.

a. Ship Characteristics. Appendix A, Ship Data and Berthing Requirements, contains information necessary for the design of fenders. For the types of ships included in appendix A, the location and protrusion dimensions of air masker bands, sonar domes, and propeller guards are shown. In

addition, FFG-7 class frigates may be outfitted with stabilizer fins which will have to be accommodated. The air masker bands and certain types of sonar domes are extremely sensitive to berthing pressures. Ordinary berthing contact with timber fender components can readily damage these items.

b. Ship Offset Requirements. For a variety of reasons, certain types of ships must, from time to time, use camels to provide an offset from the pier. Ship maintenance evolutions, including hull painting, the protection of cofferdams, etc., require an offset greater than that provided by the fender system. In addition, some types of ships require a greater offset at all times due to hull configuration or deck overhang. Consequently, the pier fender system must accommodate placement of camels at appropriate points along the berth. A recent design, Pier Zulu, Charleston, SC, utilized 7-foot diameter by 14-foot long, cylindrical foam-filled fenders as the primary system, and provided vertical trapezoidal rubber fenders along the pier face between the foam-filled fenders. See figure 50 in DM-25.1 and figures 4-1 and 4-2 in section 4. The trapezoidal fenders can accommodate camels.

An analysis of the characteristics of types of ships to be berthed will establish those requiring offset at all times and optimum locations for camels. These constant camel placements can be overtly provided for in the design. Intermittent, specific camel locations, such as for pier repairs or varying ship type or location, cannot be predicted. To provide berthing flexibility, as practical, the entire berth length should be suitable for the placement of camels.

5.3 Types of Resilient Fenders

The following discussion of types is arranged in four categories based on methods of construction:

- Fender piles.

- Rubber fenders firmly fixed to the pier.
- Floating and suspended rubber fenders attached to the pier or other fender system components.
- Miscellaneous and composite designs.

The term "rubber" is generic covering all types of natural rubber and synthetic elastomers.

5.3.1 Fender Piles. DM-25.1 discusses and illustrates resilient timber and steel piles in a conventional design backed by hollow rubber dock fenders. It also shows a method of protecting a pier with steel tubular piles designed to accept the entire lateral berthing load. The monopile fender system is a sophisticated version of that type.

a. Monopile Fender System. A monopile is a hollow steel pile fabricated by welding individual cylinders end-to-end. Each individual cylinder of the monopile structure has the same outside dimeter, but wall thickness, alloy content, heat treatment, and/or length will vary between stages. These individually tailored stages maximize the energy absorption capability of the composite piling increasing the efficiency of the monopile fender over the flexible pile fender.

The term flexible pile is often used interchangeably with the term monopile due to physical similarities. There are important differences, however.

The flexible pile is a pile of uniform cross section throughout its length, constructed of material or combination of materials that are reasonably elastic. Steel is usually employed because of its cost, cross-sectional properties, and ability to be fabricated in extremely long lengths. These properties allow steel piles to absorb a significant amount of energy in

flexure. Flexible pile systems are efficient and cost effective in offshore applications; however, most harbors do not have sufficient depth to fully develop their energy absorption potential. Consequently, only the monopile is considered suitable for harbor structures.

The monopile structure itself is generally capable of absorbing and dissipating between 30% and 35% of the impact energy. The remaining 65% to 70% is absorbed by means of an integrated rubber fender attached to the monopile structure (figure 5-1). The type of rubber fender most commonly employed with the monopile fender system is the "cell" fender (paragraph 5.3.2). Field reports indicate excellent routine performance capability and cite occasions where sizable overloads have been imposed on the monopile structure without inflicting permanent damage.

The monopile fender system is presently considered to be cost prohibitive by many; however, recent trends toward computer-aided design and manufacture may reduce the cost sufficiently to make the monopile fender system a cost-effective alternative.

5.3.2 Rubber Fenders Fixed to Pier. DM-25.1 discusses and illustrates the following types:

Rubber-in-compression Fender Units of the following shapes: cylindrical, rectangular, trapezoidal, wing type, D-shaped and rectangular urethane-capped. These fenders are used directly affixed to the pier or wharf face and act as resilient backing for fender pile systems.

Rubber-in-Shear Fenders - The Raykin fender.

The following augments and expands that information.

a. Classification. Rubber fender products can be operationally subdivided into three classes: compression, buckling, and shear.

(1) Compression. The compression fender is technically a misnomer but descriptive of the action that takes place. Solid rubber, although elastic, has a bulk modulus similar to water and is considered to be almost incompressible. In order to make rubber soft, flexible, and capable of absorbing energy through compression, one of two variations is employed. The first variation (figure 5-2) involves making the center of the fender hollow and open to the surrounding atmosphere. This allows the thick outer rubber shell to bulge outward absorbing energy. The second variation (figure 5-3) also involves a hollow center, but closed to the surrounding atmosphere. This allows the thin outer rubber shell to compress its gaseous center absorbing energy.

Most products classified as compression fenders incorporate the first variation and consist of extruded and wound rubber shapes commonly used as rub rails on vessel hulls, barges, and berthing structures or as resilient spaces between an abrasion fender and a fixed structure.

The performance curves for these fenders are nonlinear and generally quite similar. Fenders having a curved rather than flat external surface increase in stiffness more gradually as the area of contact increases during deformation. These fenders all experience a sharp and rapid increase in stiffness when the amount of deflection completely collapses the open bore, regardless of their external contour.

Compression fenders will not absorb large amounts of energy and are not generally used alone to provide resilient fendering where large berthing loads are encountered.

(2) Buckling. The buckling fender operates on the buckling column principle in which a molded column of solid rubber is loaded axially

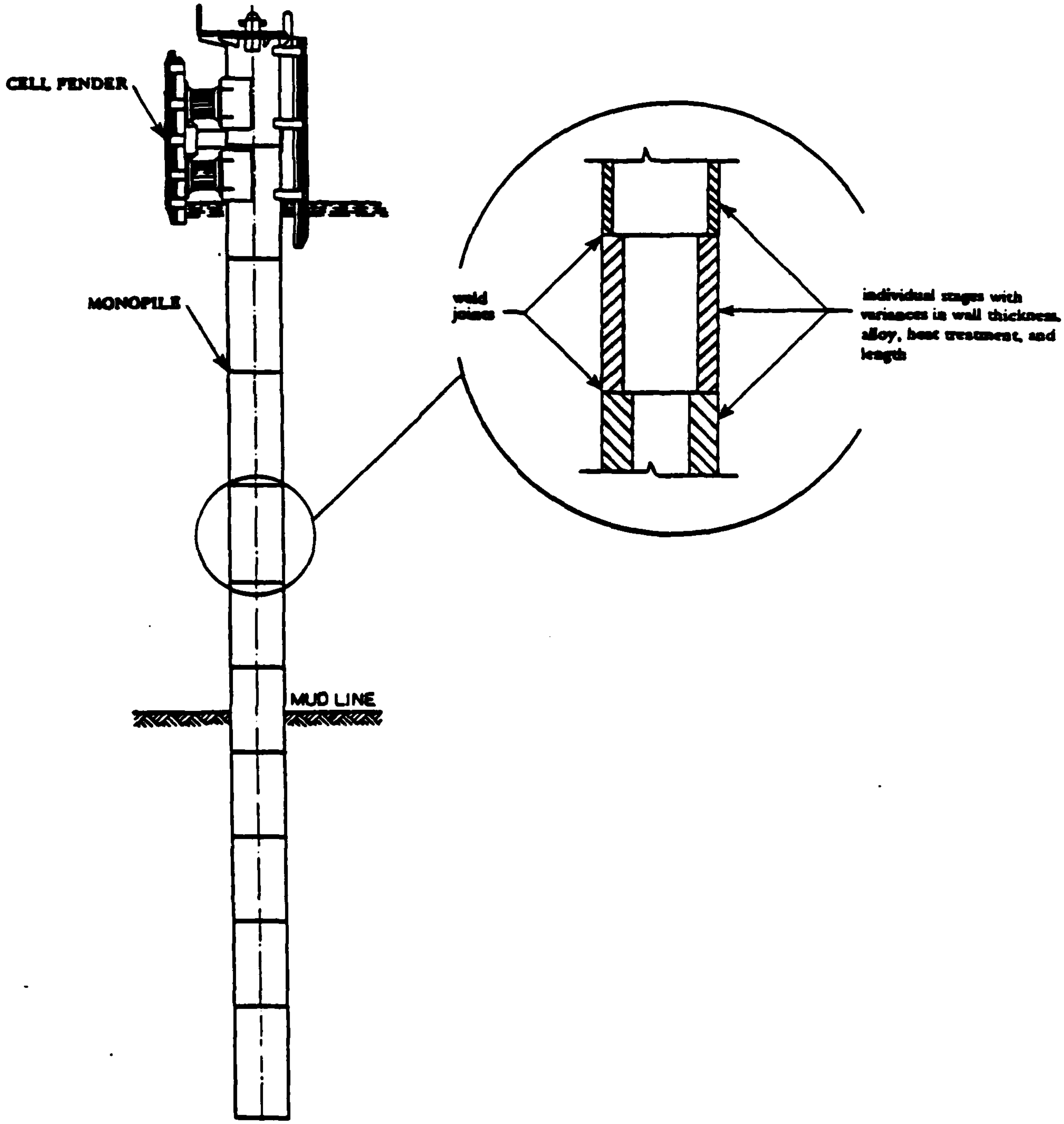
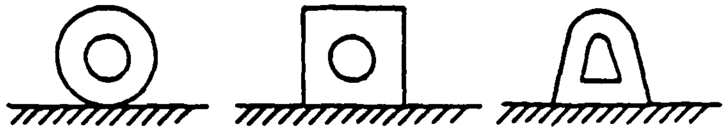
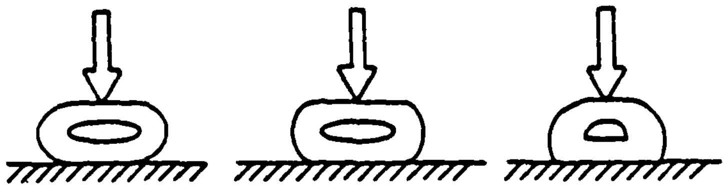


Figure 5-1. Typical Monopile Design.



(a) Cross section – unloaded.



(b) Cross section – loaded.

Figure 5-2. Open Compression Fender.

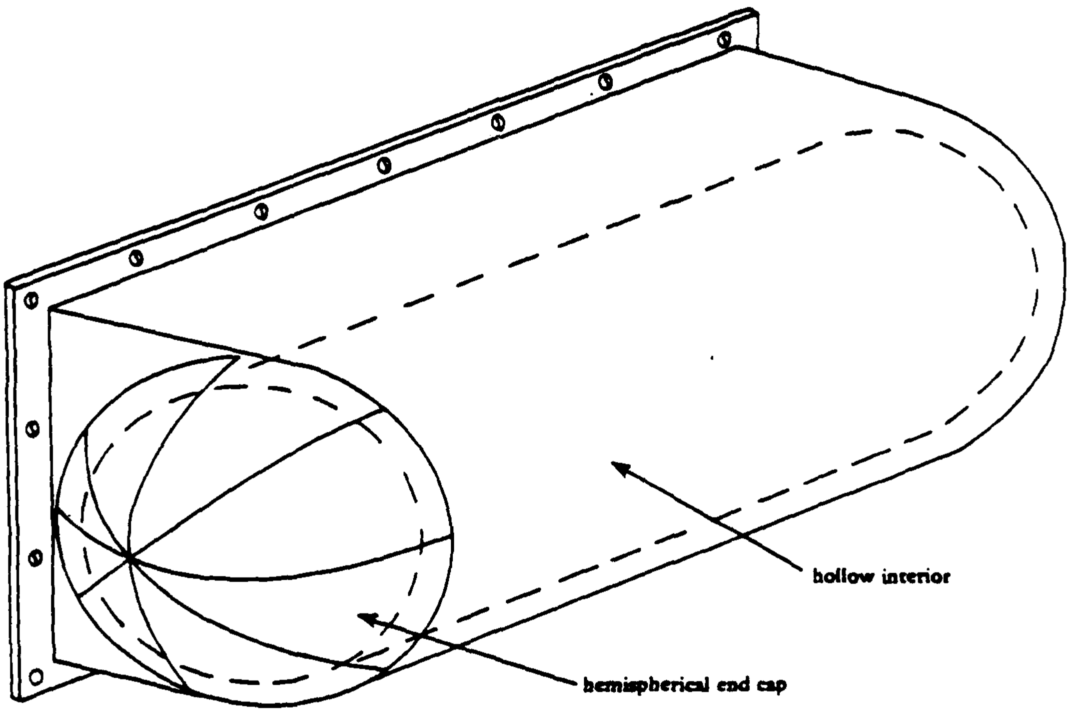


Figure 5-3. Closed Compression Fender.

until it buckles laterally. This buckling action is similar to the bulging action of the compression fender. The fundamental difference between the two is the way in which the load is applied. A hollow rubber cylinder loaded laterally is classified as a compression fender; its thick walls gradually bending and bulging outward as the load is applied. The same hollow rubber cylinder loaded axially is generally classified as a buckling fender; its thick walls suddenly bending (buckling) and bulging outward laterally after the applied load has increased in magnitude.

The rubber fender product most characteristic of the buckling fender is the buckling column fender (figure 5-4), although the cell fender and various models of the trapezoidal fender are also popular. Since

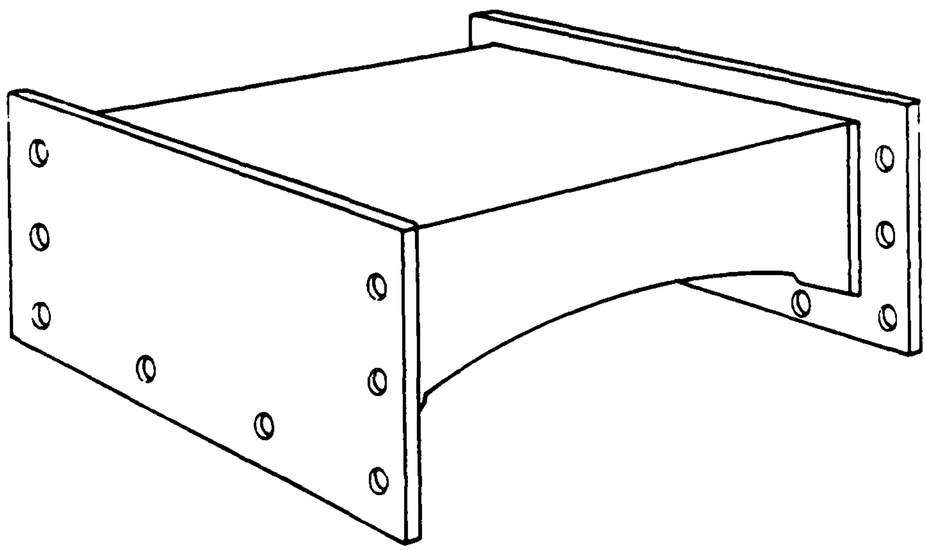
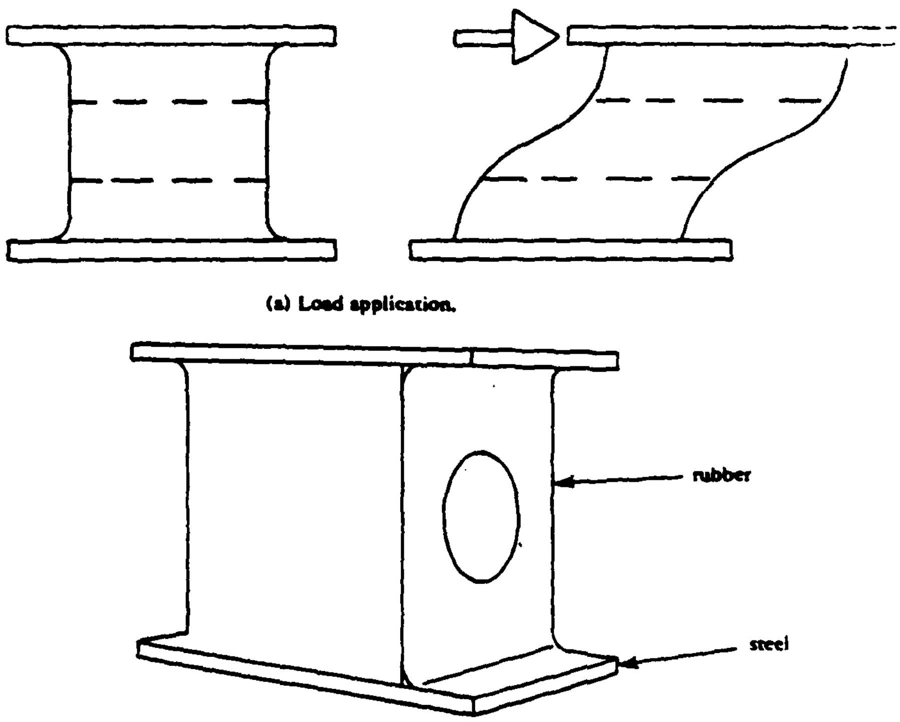


Figure 5-4. Buckling Column Fender.

the buckling column fender, cell fender, and some of the larger models of the trapezoidal fender are not well suited for direct contact with a moving vessel, they are almost always used as a resilient spacer between an abrasion fender and a fixed structure. Neither the buckling column fender nor the cell fender is capable of supporting a vertical load.

Performance curves for the buckling fender are also nonlinear and similar in shape to the compression fender. This type of fender requires a relatively large load to initiate a deflection and only a small additional increase in load to collapse the fender completely. Once deflection has been initiated, the buckling fender generally provides a much softer fender than the compression type; however, the buckling fender is intended to buckle in a predetermined direction and any lateral deflection can significantly reduce its effectiveness. Although the symmetrical deflection or buckling of the cell fender is helpful in providing greater efficiency under lateral loading conditions, the buckling fender is not as efficient as the compression fender in absorbing lateral loads. With axial loads, the buckling fender is capable of absorbing significantly larger loads than the compression fender.

(3) Shear. The shear fender (figure 5-5) relies on the elastic shearing, bending, and tensioning action of rubber to absorb energy. This fender consists of a single block of molded rubber that is chemically and mechanically bonded to two opposite and parallel steel mounting plates. As a horizontal load is applied in the plane of the plates, the block experiences a shearing stress and begins to deflect laterally in the direction of the load. The rubber block bends in a compound curvature and elongates under tension to absorb energy. The rubber adjacent to each of the bonded surfaces experiences shearing and bending action. However, as lateral deflection continues, the



(a) Load application.

(b) Example fender.

Figure 5-5. Shear Fender.

rubber between the two bonded surfaces gradually transitions from shearing and bending to tensioning.

The rubber fender product most characteristic of the shear fender is the Raykin fender (See figure 56, DM-25.1). The Raykin fender is generally regarded as the most versatile model because the individual rubber blocks are assembled in the shape of a "V" to simplify design of the fender and to minimize the required standoff distance. The number and size of the rubber blocks incorporated in the Raykin fender can be varied to adapt the fender to standoff distance and energy absorbing capability.

Since deflection of the shear fender is not limited to one direction, it is capable of absorbing lateral and tensional loads as well as

loads normal to the berthing structure. Disadvantages of the shear fender are the large standoff distance due to its large deflection requirement and premature failure of the metal/rubber bonds due to rust undercutting.

b. Performance Curves. Since the performance curves for the shear fender are linear, while the compression and buckling fenders have nonlinear performance curves, a comparison indicates that the initial reaction of the shear fender is similar to that of the compression fender, but much softer (lower and more gradually increasing) than the buckling fender. After initial deflection, the intermediate reaction of the shear fender generally becomes softer than that of the compression fender. Towards the end of travel, the reaction of all three fenders becomes essentially the same due to compression of solid rubber.

c. Air Block Fender. The air block fender (figure 5-6) has a shell construction similar to the floating pneumatic fender. Its shape resembles a floating pneumatic fender cut in half across the cylindrical portion of the fender body. The shell is chemically bonded and mechanically coupled to a rigid circular mounting plate. This is a "fixed" pneumatic fender and is mounted on the solid face of berthing structures. The maximum diameter of the air block fender that can be employed is limited by the physical dimensions of the mounting surface and requires closer spacing of the individual fender units than would otherwise be necesary. The shell thickness varies between 3/8 and 1/2 inch. Small and medium size units are generally capable of containing the high internal pressures that result from overload conditions without further protection. However, the large size fender units cannot withstand higher tensile stresses and incorporate a compression, or deflection limiter within the body rather than a relief valve to protect them. Because of the "fixed" nature

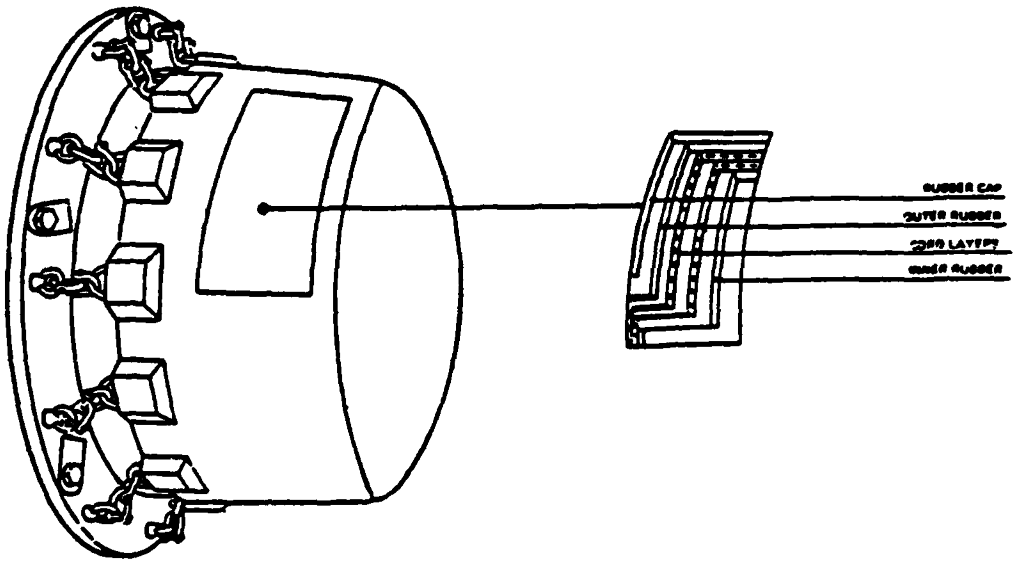


Figure 5-6. Air Block Fender.

of the air block fender it is used only at dedicated berths with sufficient mounting surface.

A variation of the air block fender is the air cushion fender (figure 5-7). The shell is constructed in the same way as the air block fender but instead of being both chemically bonded and mechanically attached to a thick rigid mounting plate, it is chemically bonded to a thin rectangular steel mounting plate. The air cushion fender was primarily developed for use on offshore drilling platforms to protect the platform legs and supply boat hulls from damage.

d. <u>Cell Fender</u>. This type is a cylindrical buckling fender, usually used in multiples, attached to the pier face with a rigid plate. The cells are faced with an abrasion plate for ship contact which enables the cells to act as a unit. See figure 5-8.

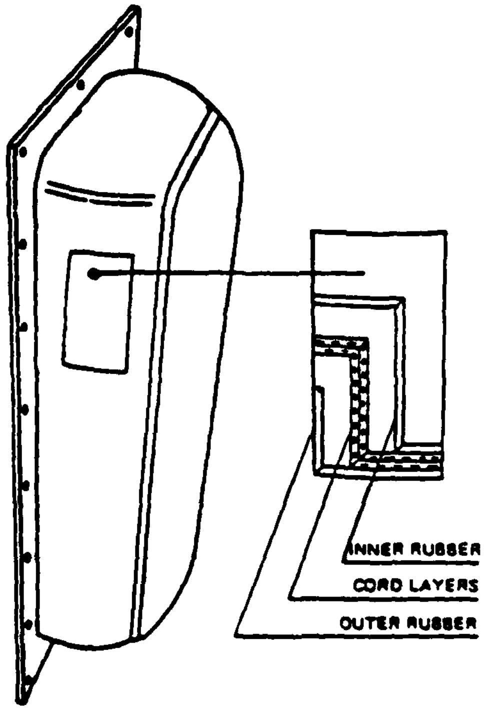


Figure 5-7. Air Cushion Fender.

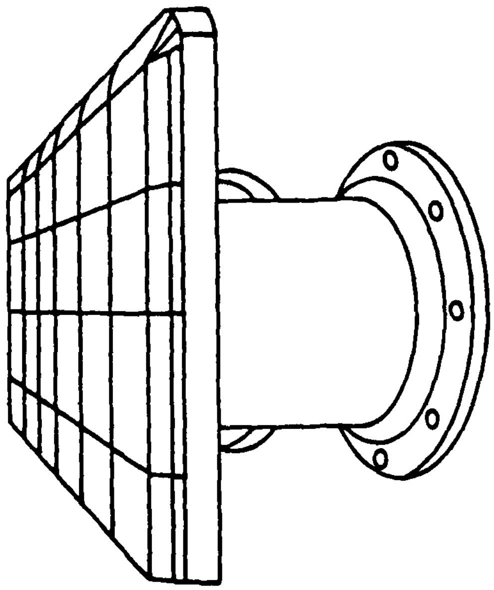


Figure 5-8. Cell Fender.

The conceptual design of a Navy floating pier (section 4) uses this type of fender. A unit is comprised of three 3-foot diameter cells. To keep the contact area narrow, this concept has a face plate only 2.5 feet in height and the 3-cell unit is 15 feet long. Units are provided every 25 feet along the length of the pier.

The US Naval Base at Yokosuka, Japan uses a fender system similar to the above with two trapezoidal buckling units substituted for the cells, for berthing surface combatants. The contact face is about 5 feet wide by 14 feet high.

5.3.3 Floating and Suspended Rubber Fenders. DM-25.1 discusses and illustrates hollow cylindrical rubber fenders draped on a pier face in various configurations, pneumatic fenders, and foam-filled fenders. The latter type is being used more frequently in new designs and on existing piers. The following expands upon the DM-25.1 material. A preliminary procurement specification for foam-filled fenders is contained in appendix B.

a. Pneumatic Fenders. The pneumatic rubber fender employs the elastic behavior of air under compression to absorb energy. As a load is applied, the shell is deformed and the entrapped air is compressed. The rubber shell of the pneumatic fender contains the air, conforms to the surface of the vessel hull and berthing structure, and resists abrasion and tensile stresses that result during normal operation. The shell must be reinforced to prevent it from expanding excessively, which would negate the compression effort, while keeping the thickness to a minimum to enhance flexibility and minimize weight and cost. The shell has an inner and outer layer of rubber and two or more intermediate layers of wrapped and neoprene coated nylon tie cord, individually vulcanized or adhesively bonded for unity and strength.

The floating pneumatic fender (figure 5-9) is usually cylindrical in shape with hemispherical ends. The shell varies in thickness between 1/4 and 3/8 inch for smaller fender units and 3/4 and 1 inch for larger fender units. Some models incorporate fixed or swivel type mounting hardware in the ends of the fender body for ease in handling and restraining the fender during operation. Most of the larger models are not manufactured with integral mounting hardware and must be covered with an external chain, wire, or fiber net. The netting on the smaller models is usually covered with cylindrical rubber sleeving to protect the net, fender, and vessel hull from abrasion. The majority of the medium and large size floating pneumatic fenders that employ a chain or wire net, are also fitted with used automobile tires (figure 5-10) to protect the hull of the berthing vessel from the abrasion that would otherwise be caused by the steel chains or wire ropes.

The shell of small pneumatic floating fenders is generally capable of withstanding the high internal pressures and corresponding tensile stresses that result from large overloads. Since the shell of medium and large units is generally not capable of withstanding the proportionately higher tensile stresses that result from the same overload conditions, it is equipped with relief valves.

Pneumatic fenders are currently being used by the Navy as camels between nested ships. With proper sizing and the provision of bearing surface, they also can be used for pier to ship fendering.

b. <u>Foam-Filled Fenders</u>. The foam-filled fender consists of a hollow elastomer shell filled with closed-cell polyethylene foam. See figure 5-11. As a load is initially applied to the external shell it begins to deform, transferring the load to the foam filling. The cellular structure of the foam

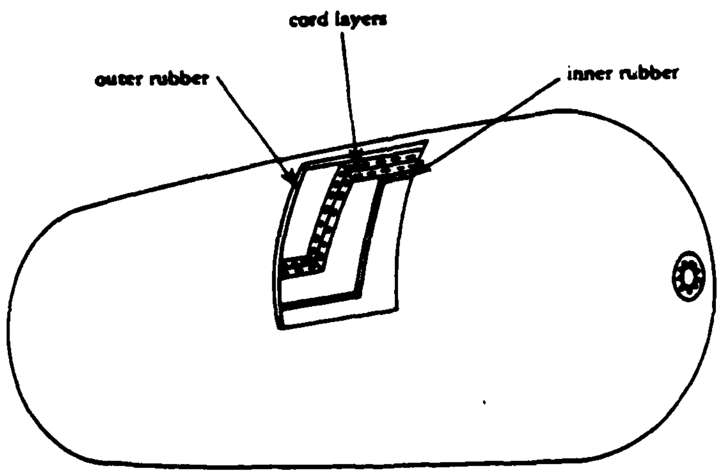


Figure 5-9. Floating Pneumatic Fender.

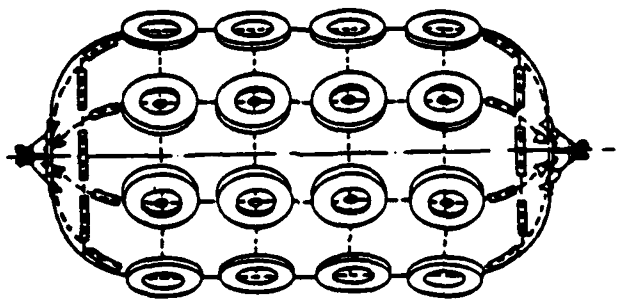
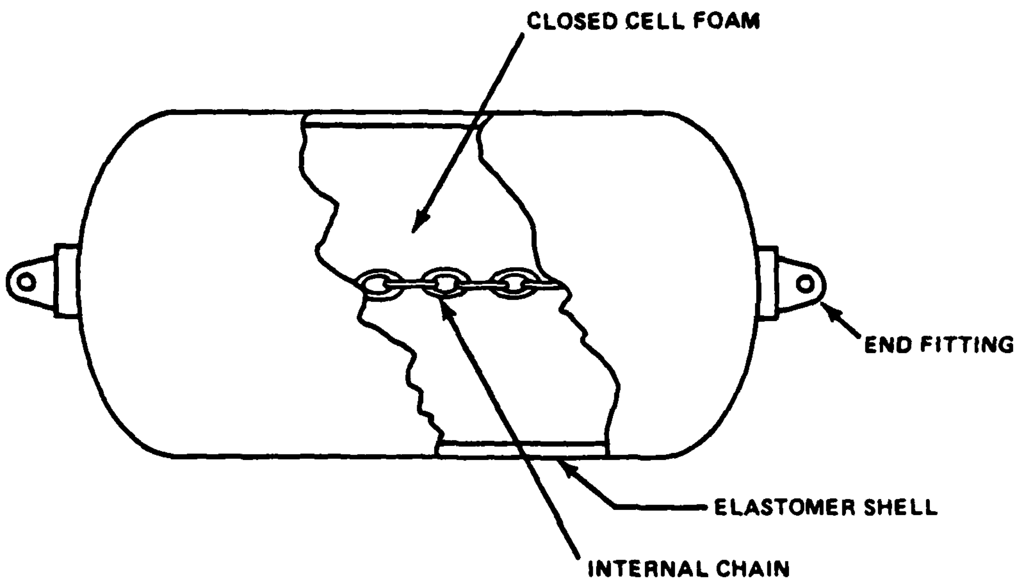


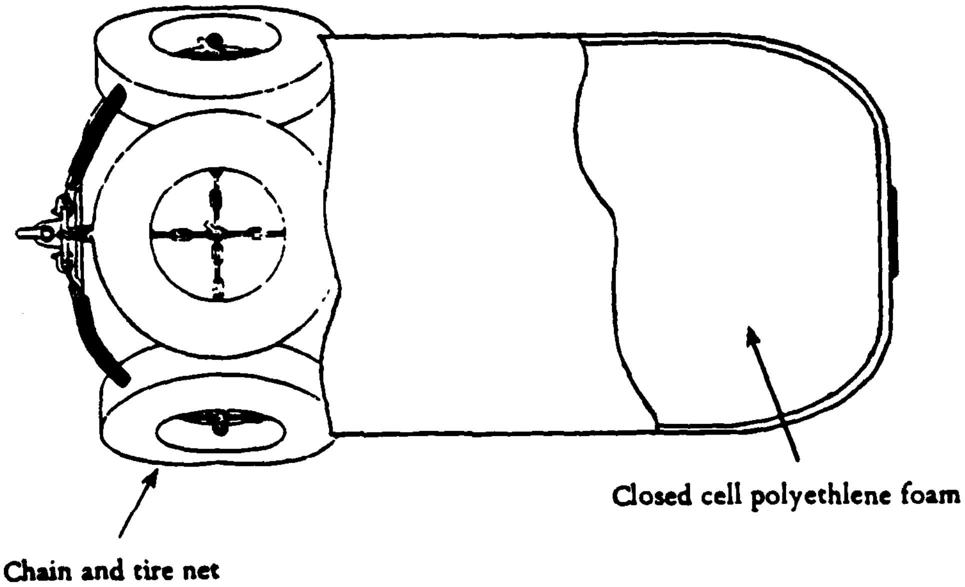
Figure 5-10. Tire Protection of Pneumatic Fender.

filling reacts like hundreds-of-millions of individual pneumatic fenders. As the fender is compressed, the cellular structure of the foam filling deforms utilizing the energy absorption of the individual cells.

The elastomer shell containing the closed-cell polyethylene foam conforms to surface configurations of the vessel hull and berthing structure, and resists the abrasion and tensile stresses during normal use. The containment of air, as required with the pneumatic fender, is not a consideration with



(a) Foam fender with internal end fitting.



(b) Foam fender with external end fitting and tire net.

Figure 5-11. Foam-Filled Fender.

the foam-filled fender, since foam contains the air within its cellular structure and tends to compress upon itself rather than bulge peripherally.

The foam-filled fender shells are constructed of similar materials, but vary with regard to the procedures used in their manufacture and the composite structure, resulting in two basic manufacturing styles and two fender types within each of these. Standard commercial fender shells are manufactured by either spray applied layers of urethane with filament nylon cord reinforcement, or dispensing urethane into a closed mold to form a cast shell. While the latter process does not lend itself to adding nylon reinforcing, it avoids potential problems inherent with spray applied urethane; i.e., influences of moisture, temperature, and solvents on the control of the urethane reaction and adhesion between layers. Both styles have found acceptance in commercial applications.

As shown in figure 5-11, there are two basic types of foam fenders: net and netless. The latter has a built in end fitting for attaching the fender while the former uses an external rigging consisting of a chain and tire net. A nylon net is sometimes substituted for the chain and tire net, primarily for use with small shipboard fenders. The netless fenders have thicker urethane skins and consequently tend to cost more than the net fenders. However, the greater hull marking of the net fender (due to the soft rubber of the tires) and occasional maintenance and replacemnt of the chain and tire net, suggest the netless fender may be the preferred choice. While early concerns were raised as to possible skin puncture and tear problems with the netless fender due to hull protrusions, characteristic of Navy ships, such problems have not materialized with either the unreinforced cast or spray reinforced style fender.

In selecting a foam fender for a particular application, consideration should be given to energy absorption requirements, bearing surface size, allowable hull pressure, stand-off distance, ease of repair, and standard manufacture sizes. For many Navy applications, the 6-foot diameter by 12-foot long fender is well suited.

Because foam fenders (and pneumatics) do not bridge the ship's stringers, hull pressure is more of a consideration. Allowable pressures on surface combatant hulls are much lower than on commercial vessels - about 15 psi for frigates and destroyers, based on NAVSEA information. The transferred pressure will be equal to the force divided by the deformer contact area. For a given fender diameter, hull pressure is approximately *proportional to* midbody length.

5.3.4 Miscellaneous and Composite Fender Designs. The following paragraphs describe five fender designs in use or proposed for various berthing purposes. They are included to illustrate the variety of resilient fender system designs being developed. DM-25.1 briefly describes and illustrates another type, the retractable fender system.

a. Hydro-Elastic Fender System for Submarine Berthing. A hydro-elastic fender system was installed at the Submarine Base, New London, on the up-river side of Pier 10 in January 1981. The fender system consists of three 30-foot square panels installed near the outboard end of the 200 foot long, pile-supported, submarine pier. The panels are constructed of an inner and outer steel frame separated by a series of end-loaded, hollow rubber cylinders located between the top and bottom structural members. In addition, the lower two-thirds of each panel is fitted with a solid front surface and a perforated rear surface, with neoprene sheeting bonded around the periphery of the panels

to form a bellows. Each of the panels is then hung adjacent to the pier on steel "H" piles so that their top surface is level with the pier. See figure 5-12.

Breasting submarines contact the individual panels, compressing the bellows and jetting contained water through the perforations at the rear of the panels for the "hydro" action, while buckling the hollow rubber cylinders for the "elastic" action.

The 90-foot-long system replaced a like section of a buckling rubber system (consisting of rubber buckling columns located between the pier face and the water). This type is installed on many of the Navy's piers with variable success.

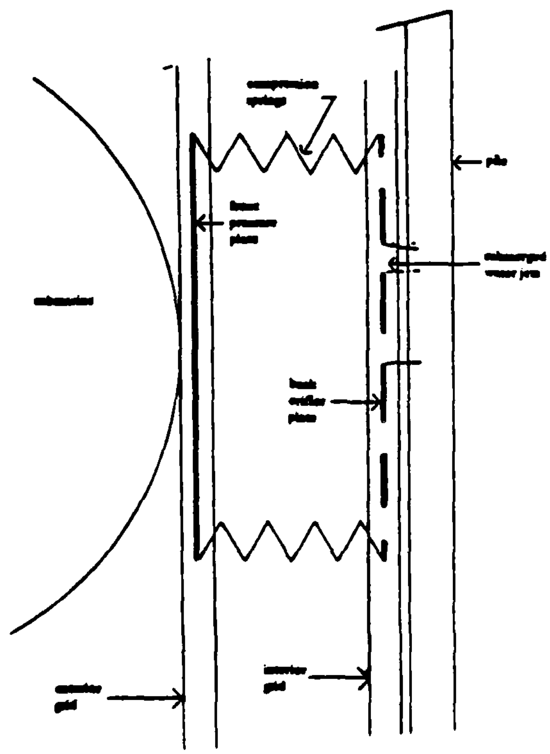


Figure 5-12. Section of Hydro-Elastic Fender.

The hydro-elastic system was designed, built, and installed on an experimental basis, to meet special operational requirements of the nuclear submarine fleet, at a cost over $2000 per linear foot. While it has performed well to date, so have the less expensive adjoining steel H-pile fenders.

b. Vertical Pneumatic Fender. Submarine Base, Pearl Harbor, considered the use of vertical floating cylindrical fender units at several submarine berths to provide the resilient fendering needed to reduce excessive timber pile breakage (figure 5-13). The concept consists of driving vertical sections of steel sheet piling adjacent to the face of piers and wharves. This will provide the required "quarter point" bearing surfaces for the vertical pneumatic rubber fender units. The fenders would incorporate their own mounting hardware and would not require netting or tires. The pneumatic units would be partially filled with water and weighted by a block of concrete attached at the lower end. Two horizontal chains would hold the individual fenders at each of the quarter point locations. The concept has recently been implemented at the US Naval Base, Yokosuka, Japan using a concrete bulkhead for a bearing surface. Results are favorable.

c. Rubber Assisted Hydraulic Fender. The hydraulic rubber fender (figure 5-14) employs the principles of hydrostatics to absorb energy. The typical configuration has a thin, closed hemispherical rubber shell filled with water. A circular mounting plate, chemically bonded to the shell, is bolted to the berthing structure. A flat bearing surface is mounted immediately outboard of the hydraulic fender so that berthing ships force it against the fender. A pipe connected near the bottom of the fender vents the water within the shell to a higher reservoir. If the reservoir is closed to the atmosphere, the air can be left at ambient pressure or raised to provide a supplementary

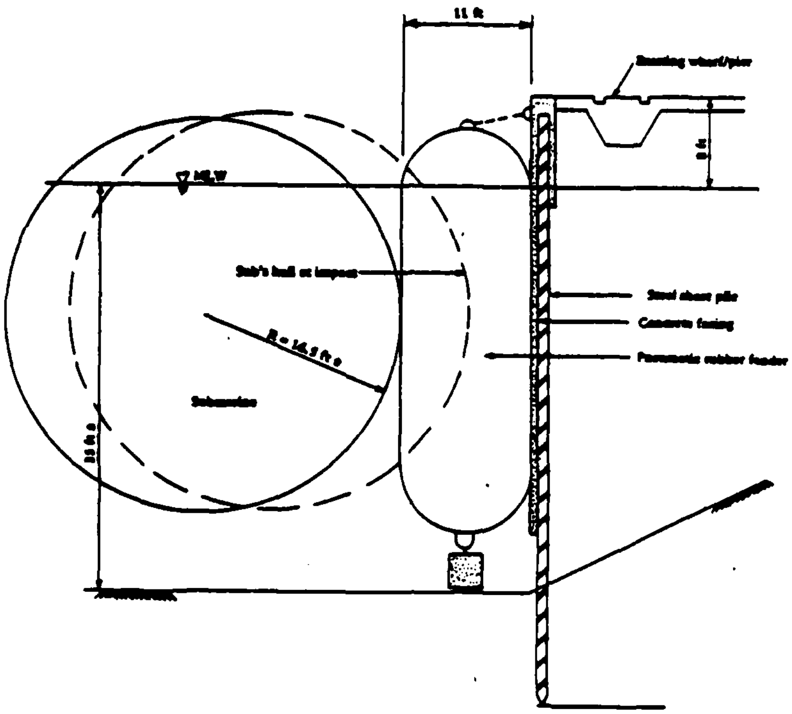


Figure 5-13. Vertical Pneumatic Fender for Submarine Berth.

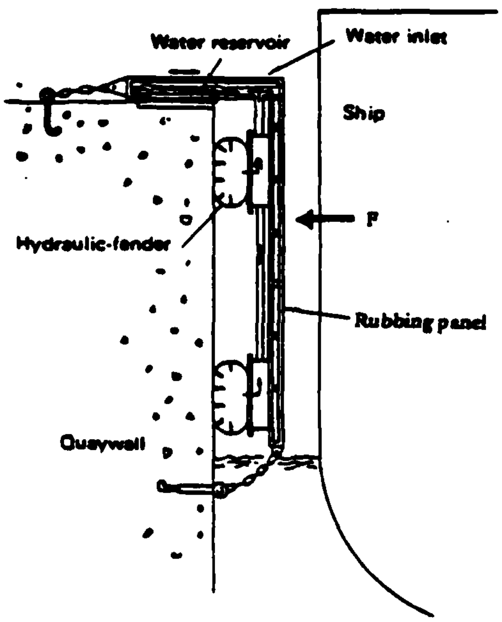


Figure 5-14. Hydraulic Rubber Fender.

"pneumatic" effect. Elevating the water will absorb a substantial amount of energy. The hydraulic fender is best suited for special applications where approach velocities are relatively high and deflection requirements are relatively small; e.g., ferry slips and container vessels.

The hyraulic fender provides as much energy absorption capability as the compression, buckling, and shear types of fenders with a lower reaction force throughout the length of travel. The reaction force can be compatible with the pneumatic fender; however, mounting surface and standoff restrictions narrow the maximum size of the hydraulic fender to approximately 23 feet in diameter by 1 foot in height, not large enough to compete in energy absorption capability.

d. <u>Pneumatic Wheel</u>. The pneumatic wheel fender (figure 5-15) consists of a heavy-duty tire and wheel combination. It is available in a variety of sizes with a single wheel or combinations of wheels mounted on the same axle. The penumatic wheel fender is recessed horizontally into the face of the berthing structure. This fender turns when laterally loaded minimizing lateral shear forces. Various models of the fender allow the shaft to move backward when being loaded, compressing springs, loading a torsion bar, or further compressing the tire by means of steel rollers positioned behind the tire. This design is used where rolling action of the wheel in combination with pneumatic tire absorption capability provide adequate protection, such as on exposed corners of piers and working surfaces of breasting and turning dolphins.

e. <u>Concrete Block Fender</u>. Another fender design, developed in conjunction with one innovative pier design concept, utilizes a rectangular concrete block on piles separated from the pier by hollow rubber resilient fenders. See figure 5-16. The dimensions are illustrative only. The fender can

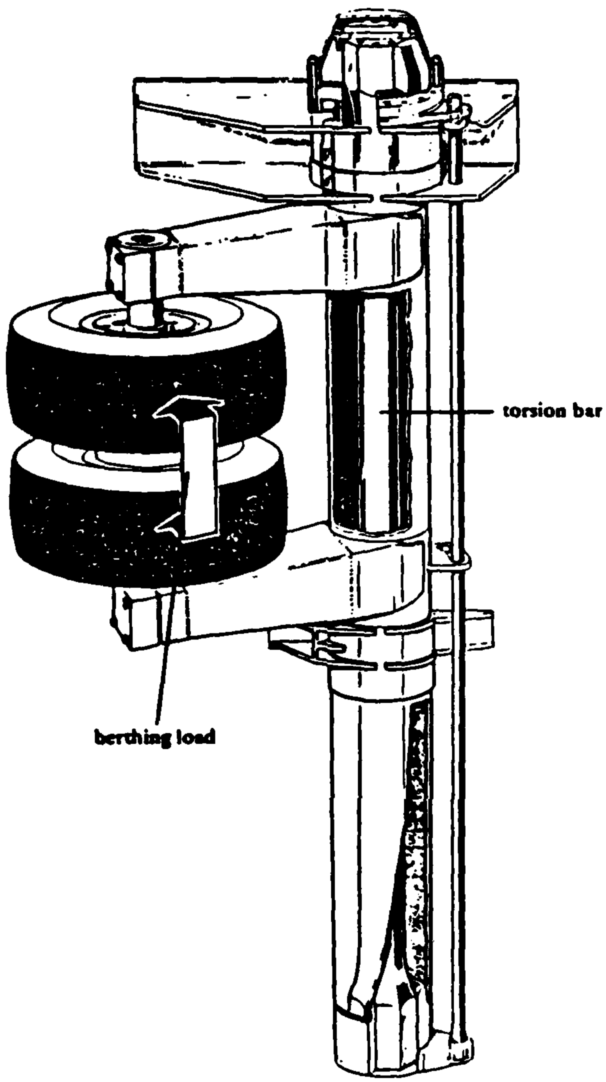


Figure 5-15. Torsion Bar Pneumatic Wheel Fender.

This fender system concept has the following advantages:

- Is readily adaptable to open piers and wharves.
- Requires little out-of-service time to accomplish construction, routine maintenance, and general repair.

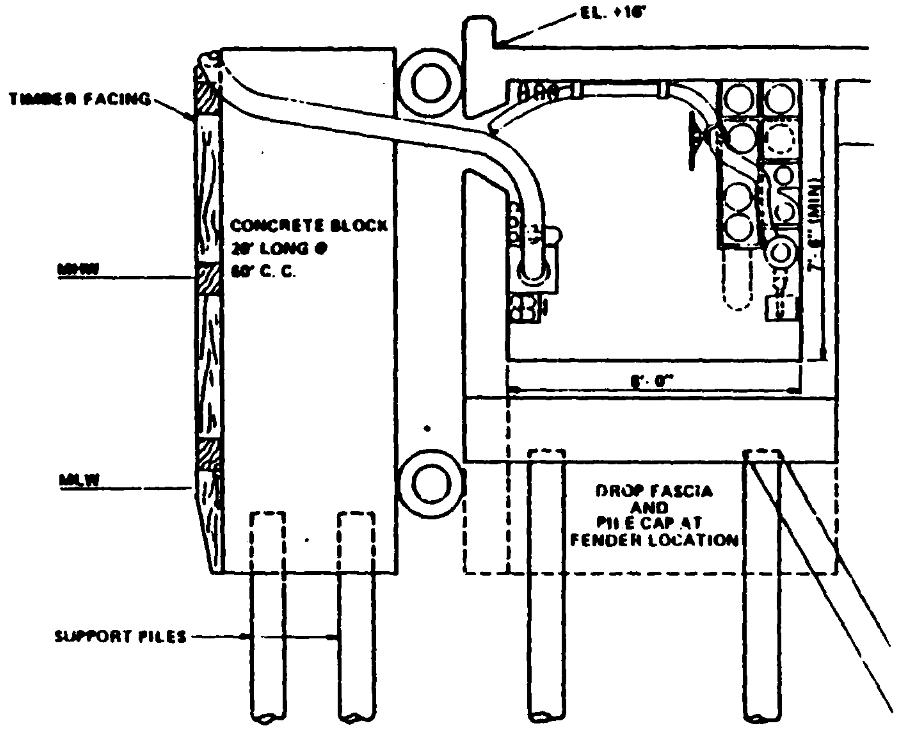


Figure 5-16. Concrete Block Fender.

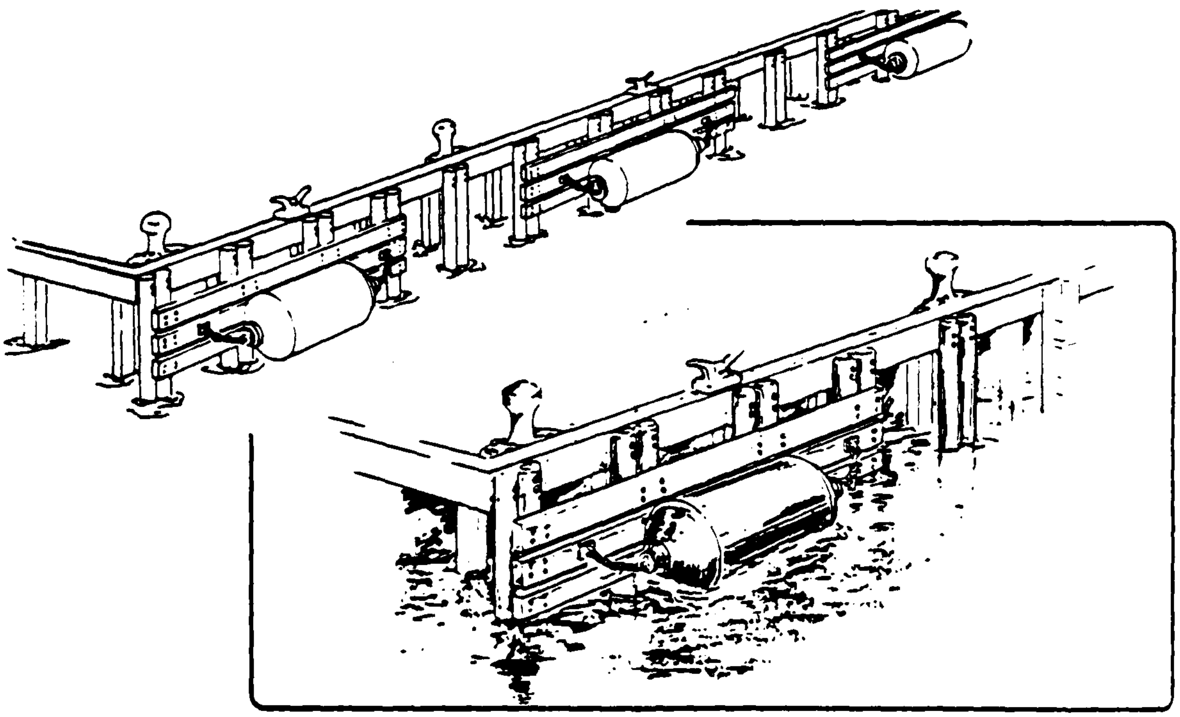


Figure 5-17. Horizontal Timber Bearing Surface for Foam-Filled Fender

be designed to fit particular ships and pier designs. One version of the concrete block fender uses a hollow core design to reduce weight and has oversized sockets to fit onto the support piles. This type can be easily replaced if damaged with another unit precast offsite.

5.4 Retrofit Concepts for Open Piers

The following describe three retrofit concepts for the use of foam-filled fenders on existing piers and one concept for the use of monopiles. These concepts are subject to further engineering analysis and field testing under actual berthing conditions.

a. Horizontal Timber Bearing Surface. This concept uses horizontal timbers attached to conventional timber fender piles (figure 5-17). The horizontal timbers provide both the fender unit support structure and a bearing surface for mounting the fender unit and developing its energy absorption potential. Foam-filled fenders are recommended with this concept because their load/deflection characteristics provide a relatively soft fender for a wide variety of vessle sizes. Mounting of the foam-filled fender similar to that illustrated allows the fender to float providing a continual adjustment to tidal variations and a degree of rotation to distribute surface wear.

- Minimizes the cost of construction, routine maintenance, and general repair.
- Maximizes anticipated service life.
- Minimizes load/deflection characteristics.
- Maximizes adaptability to varying hull contours.

b. Closely Spaced Piling. Additional piles can be driven between existing vertical pilings of the conventional fender system to provide a fender bearing surface (figure 5-18). The optimum butt diameter and spacing would

appear to be 18 inches and 36 inches, respectively. The intermittent bearing surface created is not the continuous bearing surface normally recommended by fender manufacturers, but can be used successfully in combination with the foam-filled fender provided the shell of the fender can conform to the irregularities of the bearing surface. When used in such an application, the foam-filled fender should be capable of developing a minimum of 70% of its energy absorption potential. Selection of an optimum foam-filled fender for this application would, therefore, dictate the use of either a longer or larger diameter fender unit to compensate for the energy absorption capability that will go undeveloped. Pile quality, spacing, and alignment must be given close attention for satisfactory performance and longevity. Also, the use of an intermediate wale, as illustrated in figure 5-18, should be considered for distributing concentrated loads brought about by nonuniform loading conditions.

To reduce lateral motion of the fender, thus reducing the length of bearing surface required, the fender can be mounted as shown so that it is suspended at low and intermediate tide levels. As the fender floats at high tide, rotation would occur to minimize wear.

Advantages and disadvantages of the concept are the same as the previous concept.

c. Cluster Pile Bearing Surface. This is a grouping of tightly driven timber piles formed in two rows and bound together with wraparound wire rope (figure 5-19). An irregular face timber wall is provided onto which a resilient floating fender will have direct contact against the piling. Energy absorption is not adversely affected by the irregular interface and abrasion between the piling and resilient fender skin will be reduced by the fender's protective chain and tire net. Once again, this concept requires minimal alteration of a conventional timber fender system. It has considerably more

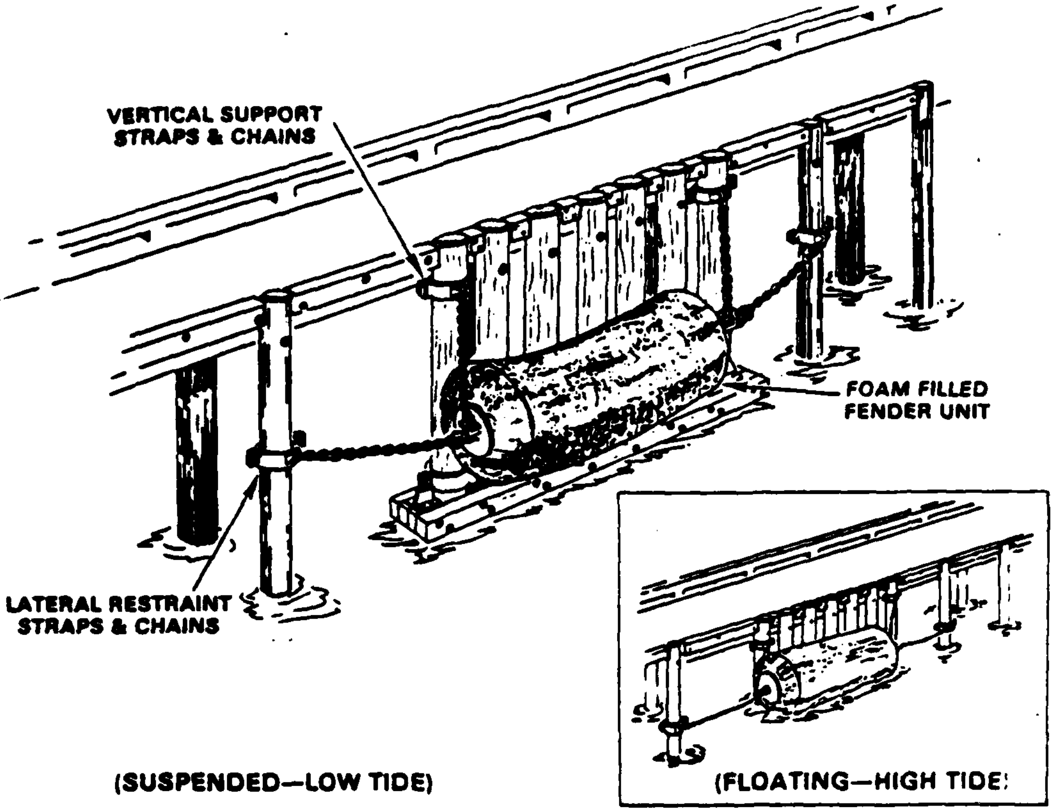


Figure 5-18. Closely Spaced Piling for Foam-Filled Fender.

more lateral load resistance than the horizontal timber strip concept because of more fender piles acting as a unit. Pile quality and alignment should be given close attention if satisfactory performance and longevity are to be achieved. Construction costs will be higher, directly proportional to the quantity of extra fender piles. One distinct disadvantage associated with this concept is the uncertainty surrounding the availability of good quality timber products and of obtaining timber piles in the future.

d. Precast Concrete Bearing Wall. A fourth concept, illustrated in figure 5-20, involves the removal of portions of the existing timber fender system to allow installation of precast, reinforced concrete bearing walls adjacent to the pier cap. Upon removal of the selected sections of timber pilings, chocks, and wales from the conventional timber fender system, steel pipe

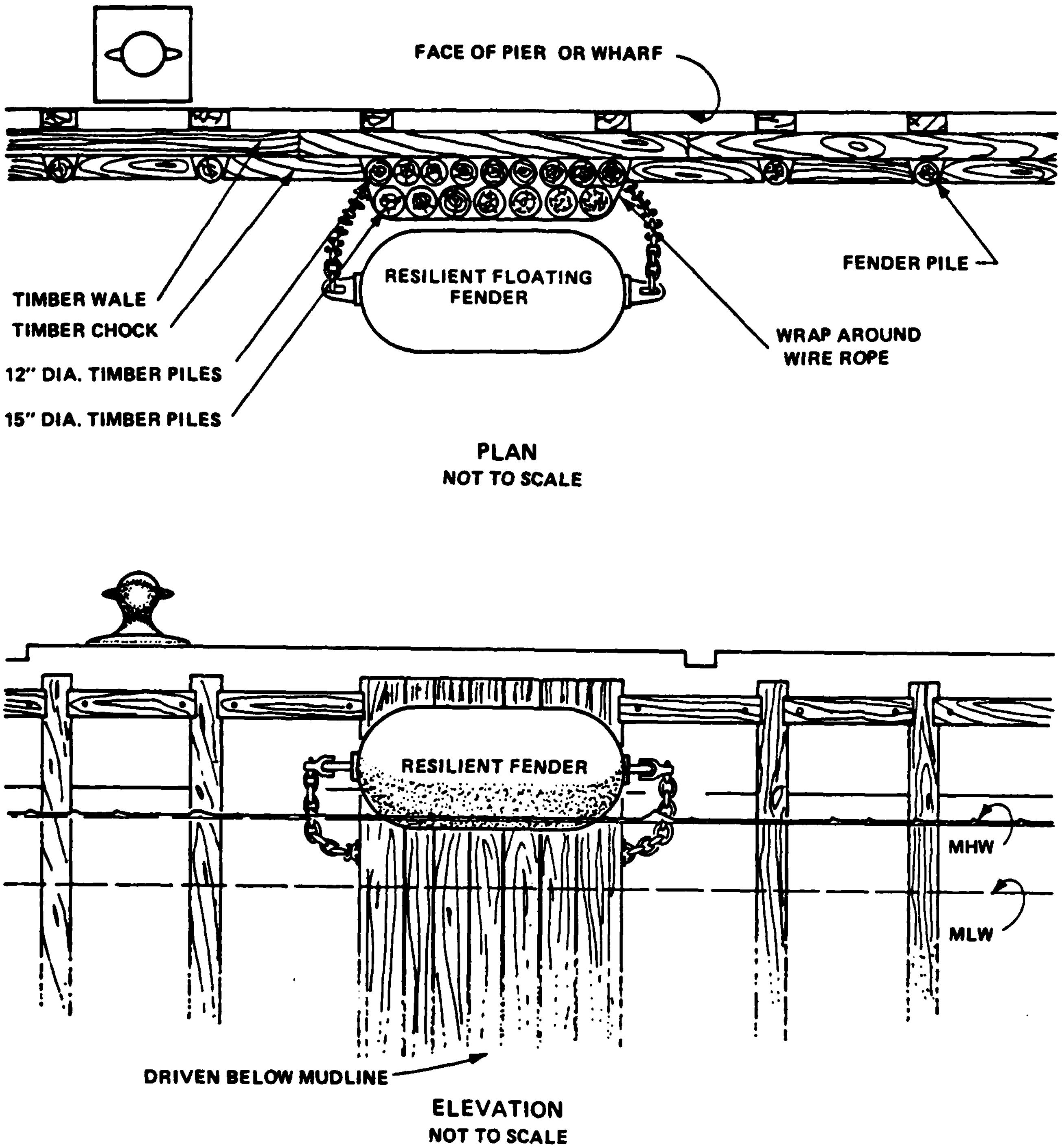


Figure 5-19. Cluster Pile Bearing Group.

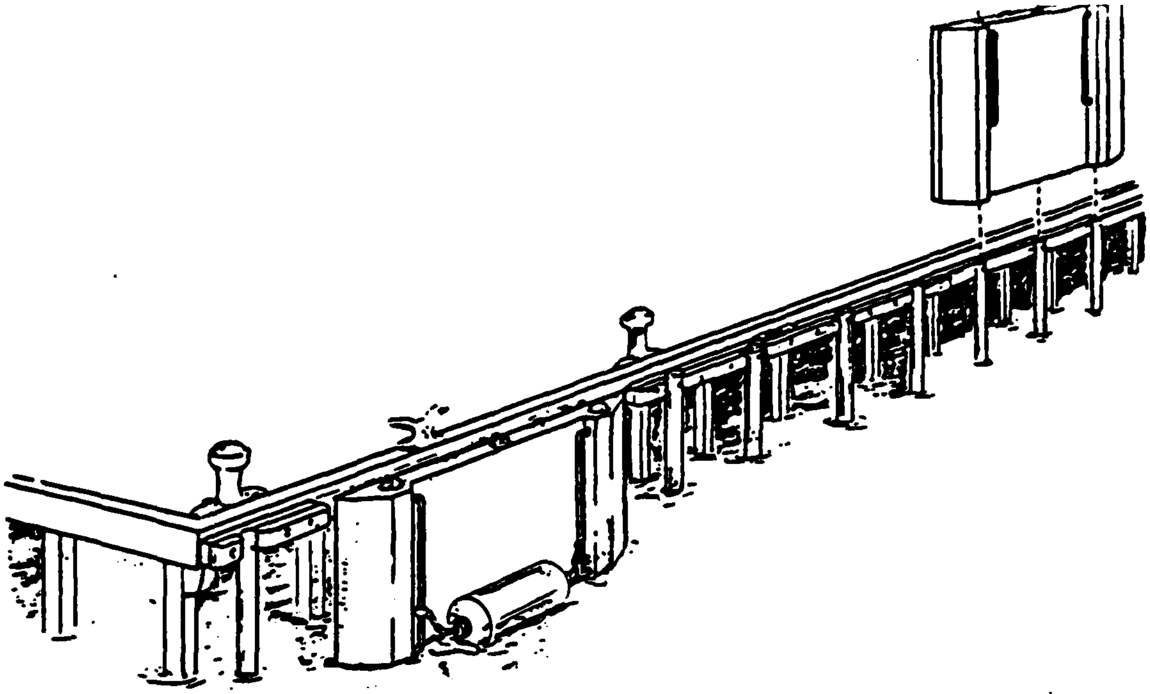


Figure 5-20. Precast Concrete Bearing Wall for Foam-Filled Fenders.

piles are driven based upon design requirements. The reinforced concrete bearing wall, fabricated offsite, is lowered onto the pipe piles and bolted or welded in place. The bearing wall is configured for a foam-filled fender unit. However, the bearing wall can be configured differently or made of different materials to accommodate the support and bearing of other types of rubber fender units. As shown in figure 5-20, the foam-filled fender is allowed to float freely to compensate for tidal variations. This is accomplished by attaching the fender to two vertical pipes or railing mounted at either side of the bearing wall. This mounting arrangement limits lateral fender movement thus minimizing bearing wall width.

Advantages and disadvantages of this concept are similar to the first concept. Although this modification increases the vessel standoff distance by the physical thickness of the bearing wall, it should substantially reduce out-of-service time for the pier and cost of construction and repair of the fender system.

e. Monopiles with Impact Panel. This concept consists of an abrasion resistant impact panel supported by monopiles (figure 5-21). Portions or all of the conventional fender system would be removed to allow installation of the panel outward and below the pier cap. After driving the monopiles, the prefabricated impact panel equipped with four-cell fender units bolted on behind would be lowered onto the two monopiles and bolted into position by means of the cell fender units. The impact panel is constructed of steel plate. Other metals, timber, concrete, or even plastics can be used to fabricate the panel. The outboard surface of the impact panel is covered with pieces of polyethylene sheeting attached with fasteners recessed below the surface of the polyethylene. In operation, this fender system absorbs the berthing energy through simultaneous buckling of the cell fender units and bending of the two monopiles. The polyethylene sheeting, by virture of its low friction coefficient, provides a relatively durable bearing surface capable of minimizing the braking action induced by any forward motion of the berthing vessel, thus preventing any overstressing of the fender system from impact loads parallel to the pier face. An overloading of the fender system in a direction normal to the pier will transfer excess energy into the pier structure by means of the pier cap bumper bar that extends above the top of the impact panel. This concept has the following advantages:

- Adapts to open piers and wharves.
- Requires little out-of-service time to accomplish construction, routine maintenance, and general repair.
- Minimizes the cost of routine maintenance.
- Maximizes the anticipated service life.
- Requires less vessel standoff distance than concepts employing foam-filled fenders.

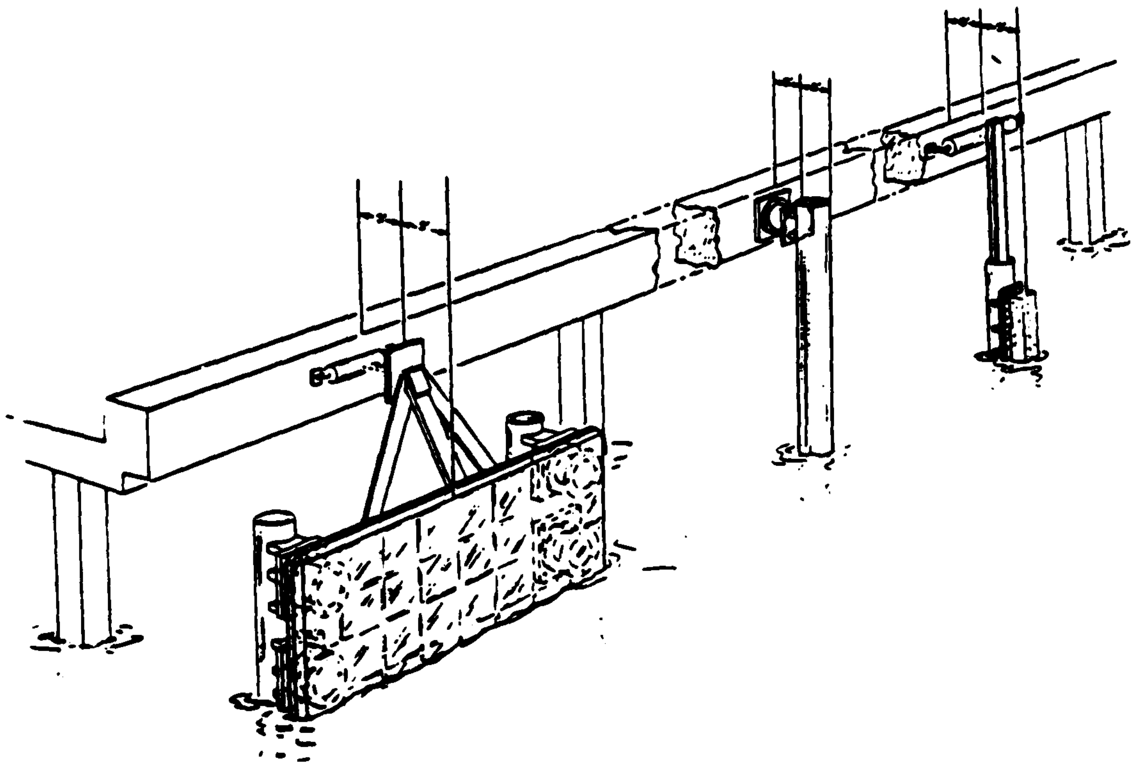


Figure 5-21. Monopiles with Impact Panel.

Disadvantages are:

- Relatively expensive to construct and repair.
- Higher load/deflection characteristics than concepts employing the foam-filled fender.
- Not readily adaptable to irregular or varying hull contours.
- Slightly higher rebound effects than concepts employing the foam-filled fender.

Although the cost of implementing this fender system concept is presently high, innovations in computer-aided design and manufacture may bring down the cost making it more competitive.

5.5 Design Procedures

The design procedures in DM-25.1 were developed in the 1940's using estimates based on displacements, angles of approach, berthing velocity and hydrodynamic theory of the time. Due to changes in ship design, and probably operating practices, these procedures are considered inadequate for the design of modern fender systems constructed to serve present and future ships. The design of more durable resilient fender systems that will significantly reduce repair/replacement costs requires accurate berthing load calculations.

NCEL is planning to develop an empirically validated model to predict berthing impact loads from which comprehensive revised design criteria, curves and monographs will be prepared for revision of the DM-25.1.

Life cycle economic analyses should be conducted when selecting fendering and camel systems. Competing fender types should be compared on the basis of cost per foot-kip of energy absorbed.

5.6 References

The material contained in this section has been extracted from the following documents:

- NCEL CR 83.007, Innovative Design Concepts-Piers for Surface Combatants, Sidney M. Johnson and Assoc., January 1983.
- NCEL Technical Memorandum, TM No. 55-83-08, Naval Pier Resilient Fender Systems Study, May 1983.
- Gee & Jenson, Plans and Specifications, Berthing Pier (MILCON Project P-136), Naval Station, Charleston, SC, 7 November 1983.

SECTION 6

UTILITIES

Major new innovative concepts have been introduced that could revolutionalize the approach to designing the layout, configuration and equipment selection associated with pier utilities services, as well as change many of the operational approaches for servicing ships. Pier Zulu at NAVSTA Charleston, SC, will be the first Navy double-deck pier with complete utility galleries on each side of the pier. Operationally, NAVSTA, Norfolk, VA and NAVSTA, San Diego, CA, are incorporating new equipment technologies developed by NCEL.

This section covers:

- Utilities requirements for small and medium surface combatants.
- The optimum design for utilities locations in reference to ship.
- Utility gallery design.
- Pier electrical distribution system.
- Pier mechanical systems.
- Other utilities including:
  - Fire protection and alarm systems.
  - Cathodic protection.

6.1 Utilities Requirements

a. General Pier Requirements

A Ship Data and Berthing Requirements Book has been prepared covering the ship characteristics and utilities requirements for the following ships:

AD-41
CG-47
DD-963
DDG-51
FF-1052
FFG-7

Appendix A includes that section of the Ship Data Book delineating the ship characteristics and utilities requirements. Table 6-1 further summarizes the specific utilities data that was available for each class of ship. The contents of table 6-1 and appendix A, while recommended for use in planning and concept studies, should be verified against site-specific conditions and requirements when approaching final design. Data for final design should be obtained from Naval Sea Systems Command (NAVSEASYSCOM) via NAVFACENGCOM (FAC 04T4) and verified with the Type Commander prior to use.

The electrical requirements for the DD-963 reflect both current need, 2800 amps, and projected need, 5300 amps, created by the addition of electric boilers and other future modifications. The service for the boilers is planned to be provided approximately 480 feet from the bow, 14 feet above design waterline, portside. The new station would be capable of receiving shore power from either port or starboard side.

The basic electrical power requirements for each ship class will be very sensitive to both temperature changes and operational status of the ship, with the demand varying between 20 to 35% of connected load for standdown and housekeeping activities in winter, to 90 to 100% for Selected Repair Activities (SRAs) and major training phases in summer.

While shipboard requirements account for the major use of electric power, on-the-pier functions are also growing, requiring increased 110/220 volt and 440/480 volt service.

- Two of the specific requirements are training vans and maintenance vans. A typical trainer in current inventory is designed to operate from a 480 volt, 3-phase, 60 Hertz (Hz), Delta, 200 amps per phase, source. One or more trainers may be required. A typical maintenance van requires low amperage, 110/220 volt service.

Table 6-1. Utilities Service Requirements.

ELECTRICAL					
SHIP TYPE	VOLTS	AMPS	3 PHASE	HERTZ	CONNECTION
AD-41	450	6,400	yes	60	16 cables, viking plugs
	450	4,800	yes	60	12 cables, feed through, viking plugs
CG-47	450	4,000	yes	60	10 cables
DD-963	450	2,800	yes	60	7 cables, short pigtails
	450	2,800	yes	60	7 cables, planned for boilers
DDG-51	450	4,800	yes	60	12 cables, MIL-C-24368 receptacle
FF-1052	450	1,200	yes	60	3 cables, pigtails, lug conn.
FFG-7	450	2,800	yes	60	7 cables, MIL-C-24368 receptacle

STEAM			
SHIP TYPE	PRESSURE (PSI)	DEMAND (LB/HR)	CONNECTION
AD-41	150	-	Two, 2" hoses; Manifold with four-2" angle valves
CG-47	150	9096	Nipple threaded connection
DD-963	100	-	One 2-1/2" connector with 1-1/2" reducer
DDG-51	NA	NA	None, electric boilers
FF-1052	150	-	One 2-1/2" connector with 1-1/2" reducer
FFG-7	100		One 2" IPS flexible steam hose, 2 outlets

POTABLE WATER			
SHIP TYPE	PRESSURE (PSI)	DEMAND (GPD)	CONNECTION
AD-41	90	85,000	2-1/2" Hose
CG-47	-	12,000	2-1/2" Hose
DD-963	-	17,000	One 2-1/2" Hose
DDG-51	50	-	2-1/2" Hose
FF-1052	33	15,000	One 2-1/2" Hose
FFG-7	50	10,750	One 1-1/2" Hose Valve

SALT WATER			
SHIP TYPE	PRESSURE (PSI)	DEMAND (GPM)	CONNECTION
AD-41	150	-	3-1/2" Hose valve with siamese connection
CG-47	-	1740	2-1/2" Hose
DD-963	150	1100	2-1/2" Fire hose
DDG-51	150	2000	2-1/2" Hose
FF-1052	125	-	2-1/2" Hose
FFG-7	150	-	2-1/2" Hose

Table 6-1. Utilities Service Requirements (Continued).

SEWAGE			
SHIP TYPE	GPD	GPM	CONNECTION
AD-41	102,000	-	Ball valve with male quick disconnect; 4" hose
CG-47	-	200	4" ball valves, Aeroquip Type 2580
DD-963	20,600	-	6" plastic hose, Aeroquip Type 1503
DDG-51	-	100	4" hose, Camlock connection
FF-1052	18,000	-	6" plastic hose, Aeroquip Type 190016
FFG-7	12,900		4" hose, 2 outlets

LUBE OIL			
SHIP TYPE	GPD	GPM	CONNECTION
AD-41		10	1-1/2" portable angle valve & funnel
CG-47		10	2-1/2" hose, valved hose connection & funnels
DD-963		-	2-1/2" screw on connection hose
DDG-51		10	Valve and funnel
FF-1052		-	1-1/2" deck fitting connection
FFG-7		-	4 tanks, funnel or valve hose adapter

COMPRESSED AIR		
SHIP TYPE	PRESSURE (PSI)	CONNECTION
AD-41	100	1-1/2" hose, quick disconnect
CG-47	-	--
DD-963	100	One 3/4" hose, quick disconnect
DDG-51	125	Globe valve and hose connection
FF-1052	100	One 3/4" hose, quick disconnect
FFG-7	125	3/4" hose

TELEPHONE		
SHIP TYPE	LINES	CONNECTION
AD-41	-	6 direct, 4 trunk, 6 feed thru
CG-47	10	Standard arrestor, box connection
DD-963	10	Two conductor cable, screw terminal connection
DDG-51	10	--
FF-1052	7	Two conductor plugs
FFG-7	7	--

Table 6-1. Utilities Service Requirements (Continued).

OILY WASTE			
SHIP TYPE	GPD	GPM	CONNECTION
AD-41	5000	-	2-1/2" IPS male quick disconnecting fitting
CG-47	5000		--
DD-963	5000	-	One 2-1/2" hose, standard connection
DDG-51	-	100	2-1/2" hose, Camlock connection
FF-1052	5000	-	1-1/2" hose, female connection
FFG-7	5000	-	One 2-1/2" hose

FUEL OIL (JP 5)			
SHIP TYPE	PRESSURE (PSI)	GPM	CONNECTION
AD-41	40	-	Two 4" hose connection
CG-47	40	200	2-1/2" hose
DD-963	-	-	--
DDG-51	40	250	2-1/2" host
FF-1052	-	-	2-1/2" hose
FFG-7	100	-	4" hose, threaded connection

FUEL OIL (F-76 NAVAL DISTILLATE)			
SHIP TYPE	PRESSURE (PSI)	GPM	CONNECTION
AD-41	100	600	7" hose
CG-47	40	600	7" hose
DD-963*	100	-	Quick release probe
DDG-51	40	2400	6" hose (forward) and 7" hose (aft)
FF-1052	-	-	Quick release probe
FFG-7	100	-	7" hose

Note: *Standard Marine Diesel.

- Major requirements exist in support of SIMA and SUPSHIPS maintenance, repair, and alteration activities. The power requirements supporting these activities would be a function of activity level.

The ship steam demand is found to vary predominantly with the daily mean outdoor temperature, and selection of a design temperature depends upon the station location. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) provides design temperature levels based on 97.5 and 99% time durations. Temperatures at other durations are extractable from NAVFAC P-89. The National Oceanic Atmospheric Administration (NOAA) offers temperature and pertinent information at other station locations.

Considerations other than the yearly temperature profile may dominate in selecting the design temperature. These would include local conditions which can cause significant variations from temperatures reported by the Weather Bureau, and actual performance specified by the Fleet.

All ship types and classes generally produce similar steam flow rate excursions, differing only in magnitude. Some typical daily histories are portrayed in figure 6-1. Surface combatants have moderate demands and carriers have the largest, while amphibious and auxiliary ship demands fall in between.

In the typical day, steam flow demand increases near 0500 hours, indicating galley activity and general hot water use. As the morning progresses, scullery operation, noon meal preparation, and laundry operation increase the ship's steam demands. The laundry is generally secured near 1500 and the main galley and scullery near 1800. During the night time period from near 2000 to 0500, the flow rate is relatively constant.

While the steam demand histories (figure 6-1) identify times of significant occurrences, the flow rate durations (figure 6-2) provide the period of the day (in percent) that a specific flow rate has been exceeded. This information helps establish expected performance requirements of the shore

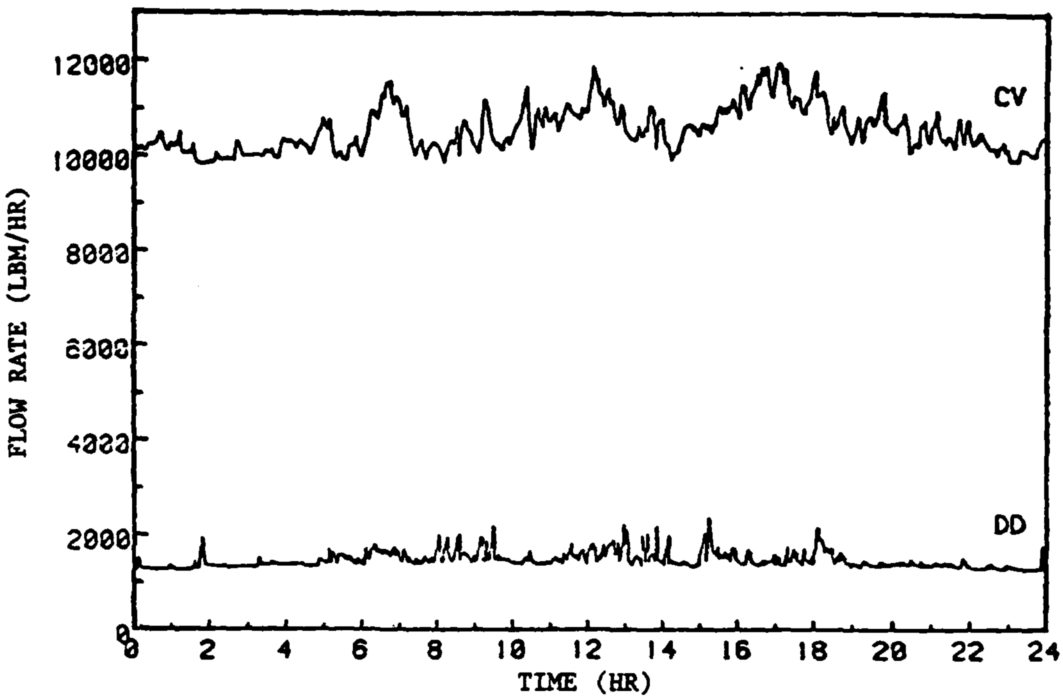


Figure 6-1. Typical Steam Service Flow Rate Histories.

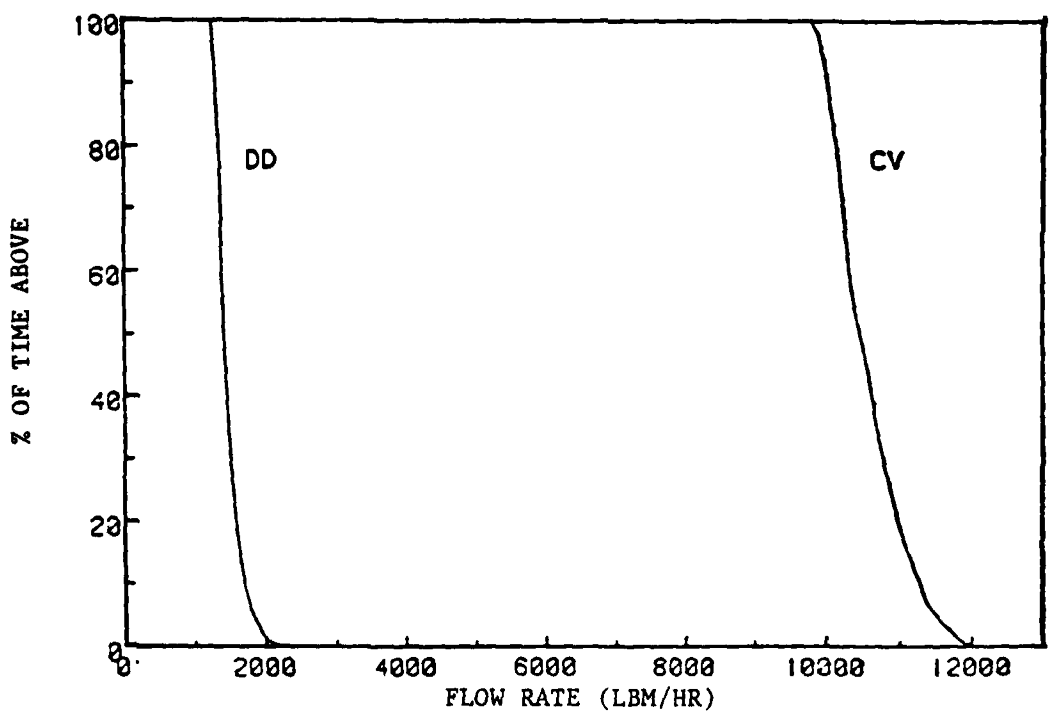


Figure 6-2. Typical Steam Flow Rate Cumulative Distributions.

boilers. It should be noted that the peak (0%) and baseline (95%) flow rates are easily recognized and will appear on pertinent design graphs (e.g., figure 6-3).

Collation and processing of daily ship steam data have revealed a distinct dependency on the daily mean outdoor temperature (e.g., FF-1052, figure 6-3). Curves representing the peak flow rate (0% time duration) and the baseline flow rates (95% time duration) are presented. As the daily mean outdoor temperature rises above 20°F, the steam demand falls until nearly 70°F, at which point temperature dependency diminishes. During a typical day at a given daily mean temperature, the flow rate lies within the bounded curves 95% of the time. For the remaining 5% of the time, the flow will be less than the baseline curve.

A multiple-ship or coincidence factor is employed to estimate the cumulative steam demand when more than one ship requires steam. Multiple Ship Factors (MSF) is defined as the ratio of the maximum coincident steam demand of the ship group to the sum of each ship's individual maximum demand.

The behavior of MSF for all ship types is similar (e.g., Surface Combatants, figure 6-4). The factor gradually decreases as the number of ships increase. When the outdoor temperature experiences a seasonal drop, the factor is higher. This is expected because winter results in a broadening of the flow rate peaks and enhances coincidence.

A review of ship type and class steam demands measured to date show the surface combatants and auxiliary vessels generally use more steam than indicated in DM-25. Steam use for carriers and amphibious warfare ships was greater at higher outdoor temperatures, but was less at the lower temperatures than is indicated in DM-25. This is partially attributed to no air wings or troops on board when at berth.

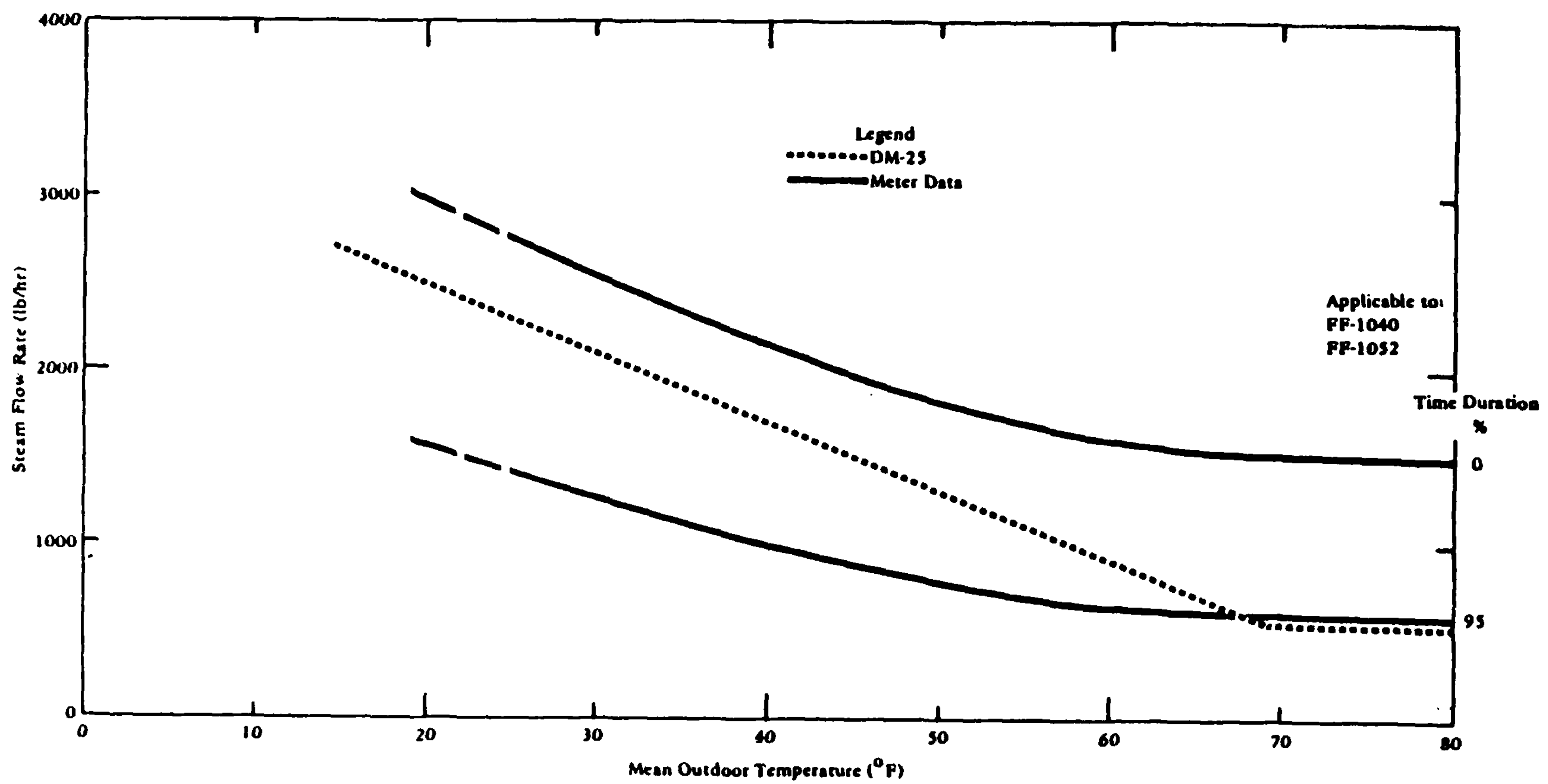


Figure 6-3. FF-1052/1040 Class Steam Measurement/DM-25 Comparison.

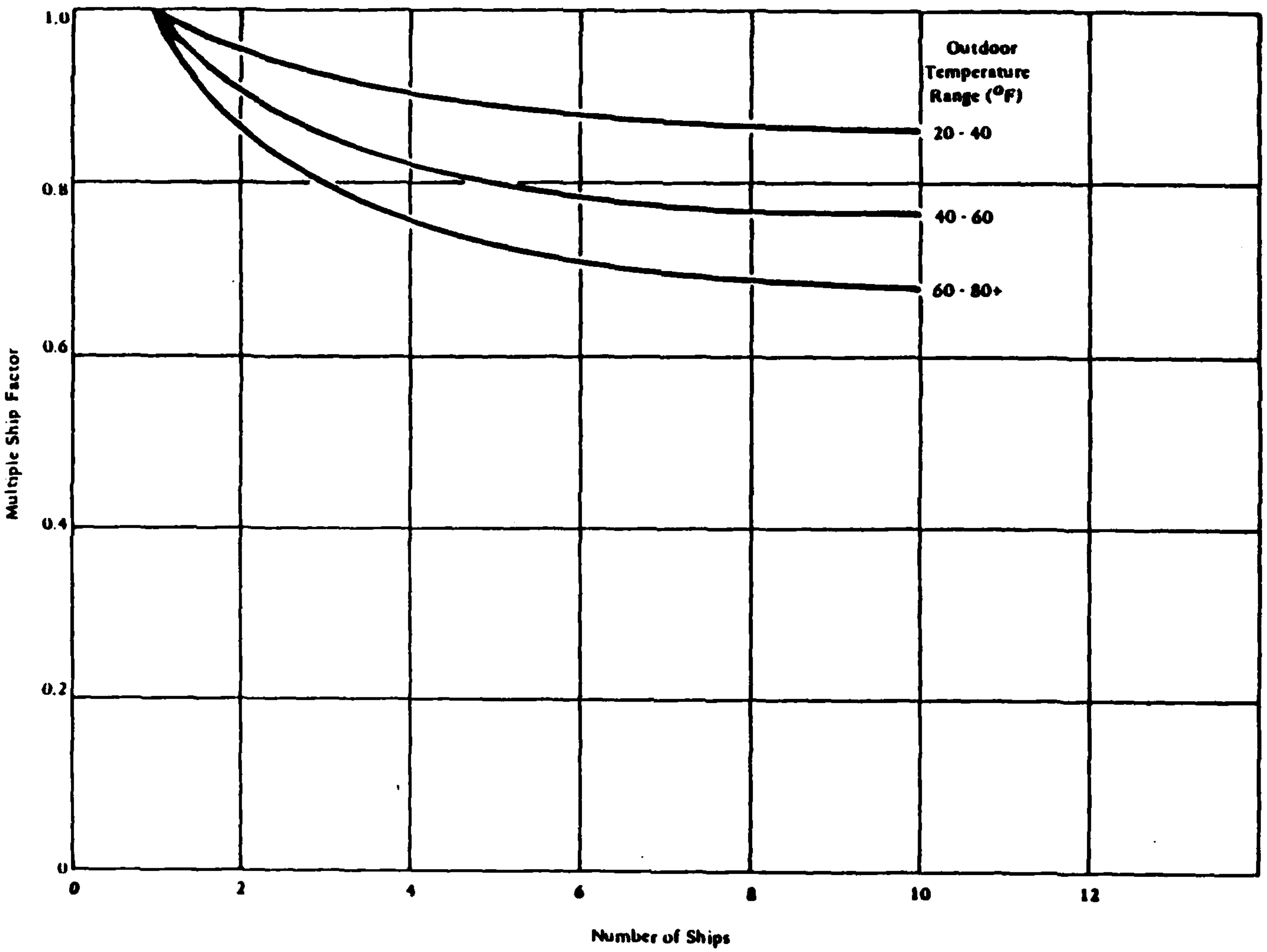


Figure 6-4. Multiple Ship Factor for Surface Combatants.

The multiple-ship factors based on measured data (figure 6-4) is sometimes higher or lower than the DM-25 value of 0.8, depending on the ship type, outdoor temperature, and number of ships.

Table 6-2 provides ship steam demands to be used based upon the baseline (95%) flow rates. The table covers both those ships that have been measured and those that have not. Those ships not measured are recognized in the table as having a single intermittent load (10°F). The flow rates at other temperatures can be secured by interpolation, assuming that a zero intermittent load occurs at 70°F.

Table 6-3 provides MSF for surface combatants, aircraft carriers, amphibious warfare, and auxiliary vessels. These are employed when summing peak flow rates within the ship type. To address an aggregate of ships where more than one ship type is being considered, several steps are necessary.

- If the total number of ships in aggregate is <u>greater</u> than nine:
  - Group the ships in types
  - Determine the peak flow rate of each ship
  - Sum the individual ship flow rates within each type
  - Multiply the total flow rate of the ship type with the appropriate MSF (table 6-3), relative to the specific ship type
  - Total the flow rates of the different ship types by adding their flow rates (MSF = 1)
- If the total number of ships in aggregate is nine or less:
  - Determine the peak flow rate of each ship
  - Sum the individual flow rates of each ship
  - Multiply the total flow rate by the aggregate MSF in table 6-3.

Table 6-2. Shore Service - Steam.[a]

Ship Type	Class	Intermittent Heating Loads[b] (lb/hr) for Outdoor Temperatures of--				Constant Load[c] (lb/hr)
		10°F	30°F	50°F	70°F	
Aircraft Carriers	CV	17,000	11,000	6,000	4,200	7,000
	CVN-65	42,000				7,000
	CVN-68	22,500	15,500	10,000	7,200	5,000
	CVT	30,000				5,000
Surface Combatants						
Cruiser	CG-4 & 10	13,000				2,200
	CG-16 & 26	4,000	2,800	1,800	1,300	1,500
	CGN-9	10,500				1,800
	CGN	3,300	2,550	2,000	1,600	1,400
Destroyer	DD	3,400				600
	DD-931	2,750	1,800	1,150	970	900
	DD-963	2,100	1,400	900	550	900
	DDG	3,400				600
	DDG-2 & 31	2,750	1,800	1,150	970	900
	DDG-40	2,750	2,200	1,750	1,500	1,600
Frigate	FF	2,400				500
	FF-1037	1,850	1,250	750	480	400
	FF-1040	2,500	1,670	900	600	900
	FF-1052	2,500	1,670	900	600	900
	FFG-1	2,450	1,600	900	600	1,100
	FFG-7[c]					
Patrol[d]	DG					
	DHM					
Submarines[d]						
Amphibious Warfare						
Command	LCC	7,000	5,500	4,700	4,100	3,000
Assault	LHA	11,500	7,500	3,800	1,600	2,500
	LPH	9,000	5,000	2,800	2,000	3,000
Cargo	LKA	4,100	3,100	2,200	1,500	1,300
Transport	LPA	21,000				3,500
	LPD	6,000	3,700	2,200	1,300	2,200
Landing	LSD	7,500	5,200	2,700	1,100	900
	LST	4,400	2,800	1,400	700	1,200

Table 6-2. Shore Service- Steam (Continued).[a]

Ship Type	Class	Intermittent Heating Loads (lb/hr) for Outdoor Temperatures of--				Constant Load (lb/hr)
		10°F	30°F	50°F	70°F	
Mine Warfare	MSO	800				200
Auxiliary						
Tenders & Repair	AD	10,200				1,700
	AD-37	12,000	8,500	6,500	5,500	4,000
	AR	12,000				2,000
	AS	12,900				2,200
	AS-31	23,200				3,900
	AS-36	12,500	7,800	4,000	2,700	2,500
Cargo & Transport	AE	3,700				700
	AFS	4,450	3,000	1,950	1,550	1,400
	AO	3,000				500
	AOE	7,600	5,600	3,600	2,600	2,000
	AOR	3,400	2,800	2,800	2,800	1,500
Tugs	ATF	1,000				200
	ATS	300				100
Miscellaneous	AG	2,300				400
	AGDS	1,500				300
	AGEH [d]					
	AGF	4,100				700
	AGFF	2,300				500
	ASR	1,200	860	520	260	600
	AVM	6,800				1,200

[a]Load based on ship's peacetime complement (no air wing, troops, or ship feedwater generation).

[b]Heating load required for normal environmental temperature of or static heat loss to ship spaces relative to the specified outdoor temperatures.

[c]Galley, laundry, hot water, etc.

[d]Not required.

Table 6-3. Multiple-Ship Factors.

Ship Type	Temperature Range (°F)	MSF for--			
		1 Ship	3 Ships	5 Ships	9 Ships
Surface Combatants	0 - 20	1	0.97	0.96	0.94
	20 - 40	1	0.93	0.89	0.86
	40 - 60	1	0.86	0.80	0.76
	>60	1	0.80	0.73	0.68
Aircraft Carriers	0 - 20	1	0.97	0.96	0.95
	20 - 40	1	0.96	0.94	0.91
	40 - 60	1	0.93	0.90	0.86
	>60	1	0.82	0.76	0.74
Amphibious Warfare	0 - 20	1	0.95	0.94	0.93
	20 - 40	1	0.87	0.83	0.82
	40 - 60	1	0.80	0.74	0.71
	>60	1	0.78	0.72	0.68
Auxiliary	0 - >60	1	0.91	0.87	0.84
Aggregate[a]	0 - 20	1	0.96	0.93	0.92
	20 - 40	1	0.93	0.90	0.88
	40 - 60	1	0.90	0.86	0.83
	>60	1	0.86	0.81	0.78

[a]Use when ship mix (more than one type) in port numbers nine or less.

b. SIMA/SUPSHIPS Requirements

If shipboard Phased Maintenance Activities outlined in OPNAVINST 4700.7F are planned at pier facilities, utilities requirements may be dependent upon the level of activity. Based upon experiences at the NAVSTA, San Diego, SIMA San Diego has cited five major utilities requirements in support of SIMA/SUPSHIPS Phased Maintenance Activities operations:

Electrical: 450 volt, 3-phase, 60 Hz, alternating current (ac) power equal to the capacity of the largest surface combatant to be serviced plus pierside contractor requirements. Projected future requirements are for 7500 amps for a single berth.

Steam: 200 psi. For steam propelled ships, certified steam is required for steam blanket on boilers. See section 6.5.4.

Fresh Water: 70 psi fresh water, 100,000 gallons per day demand.

Salt Water: 150 psi salt water.

Compressed Air: 125 psi dry, low pressure air.

6.2 Utilities Offsets

Berthing the different ships with the midship locations being at the center of the berth will offer the optimum alignment of utilities service outlets and shipboard stations. The specific locations of the shipboard utilities connections with reference to amidship locations are shown in table 6-4.

Table 6-5 shows recommended mean locations for the utilities for the design groups of ships; i.e., CG-47, DD-963, DDG-51, FF-1052, and FFG-7. The mean locations exclude servicing the AD-41 which is assumed to have a dedicated berth.

Table 6-4. Location of Ships' Utilities Connections.

		ELECTRICAL					STEAM					POTABLE WATER				
SHIP CLASS		AD-41	FF-1052	DD-963	CG-47	FFG-7	AD-41	FF-1052	DD-963	CG-47	FFG-7	AD-41	FF-1052	DD-963	CG-47	FFG-7
PORT SIDE	DECK NUMBER	3 3	02	03	01	02	4 4	1	01	01	02	3 4 4	1	01	01	02
	FRAME NUMBER	100 126	86	237	288	219	49 106	103	306	299	283	24 131 75	103	300	243	285
	DISTANCE FROM MIDSHIP (FEET) [1]	-95 -199	-8	-12	29	-30	109 -119	-56	-57	-49	-94	209 -219 5	-35	51	8	-26
	HEIGHT (FEET)	26 26	30	47	25	35	15 15	16	26	25	35	28 15 15	16	26	25	35
STARBOARD SIDE	DECK NUMBER	3 3	02	03	01	02	4 4	1	01	01	02	3 4 4	1	01	01	02
	FRAME NUMBER	100 131	86	237	288	219	49 106	103	288	292	285	24 130 77	103	240	243	285
	DISTANCE FROM MIDSHIP (FEET) [1]	-95 -219	-8	-12	29	-30	109 -119	-56	-11	-41	-96	209 -215 -3	-35	9	8	94
	HEIGHT (FEET)	26 26	30	47	25	35	15 15	16	26	25	35	28 15 15	16	26	25	35
MEAN DESIGN LOCATION (FEET) [2]		N/A	25				N/A	62				N/A	52			
MAXIMUM SERVICE OFFSET (FEET) [3]		N/A	13				N/A	51				N/A	44			

GENERAL NOTE: The DDG-51 is excluded from the table due to preliminary nature of planning data.

NOTES: 1 The midship point is taken as one-half of the ship's total length along the main deck. The distance forward of midships is shown positive. The distance aft of midships is shown negative (- sign).

2 The mean design location was calculated for both starboard and port side berthing conditions for all design ships except the AD-41.

3 The maximum service offset is the maximum distance of any service point of the design ships from the mean design location (excluding the AD-41).

Table 6-4. Location of Ships' Utilities Connections (Continued).

		SALTWATER					SEWAGE					OILY WASTE				
	SHIP CLASS	AD-41	FF-1052	DD-963	CG-47	FFG-7	AD-41	FF-1052	DD-963	CG-47	FFG-7	AD-41	FF-1052	DD-963	CG-47	FFG-7
PORT SIDE	DECK NUMBER	3 4	1	-	01 01	1	3	1 1	-	01 01	1	3	1	01		1
PORT SIDE	FRAME NUMBER	24 106	103	-	332 371	254	148	45 124	-	190 380	173	148	103	191	-	215
PORT SIDE	DISTANCE FROM MIDSHIP (FEET)[1]	209 -119	-56	-	-84 -120	-65	-287	90 -108	-	61 -129	16	-287	-55	72	-	-25
PORT SIDE	HEIGHT (FEET)	28 15	16	-	25 25	15	26	16 16	-	25 25	17	26	16	26	-	16
STARBOARD SIDE	DECK NUMBER	3 4	1	-	01 01	1	3	01 1	01	01 01	1	3	1	01	-	1
STARBOARD SIDE	FRAME NUMBER	24 106	103	-	274 381	254	148	45 124	197	190 380	170	148	105	184	-	215
STARBOARD SIDE	DISTANCE FROM MIDSHIP (FEET)[1]	209 -119	-56	-	-23 -90	-65	-287	90 -108	52	61 -129	19	-287	-60	65	-	-26
STARBOARD SIDE	HEIGHT (FEET)	28 15	16	-	25 25	15	26	21 16	26	25 25	17	26	16	26	-	16
	MEAN DESIGN LOCATION (FEET)[2]	N/A	72				N/A	73				N/A	41			
	MAXIMUM SERVICE OFFSET (FEET)[3]	N/A	49				N/A	56				N/A	23			

GENERAL NOTE: The DDG-51 is excluded from the table due to preliminary nature of planning data.

NOTES: 1 The midship point is taken as one-half of the ship's total length along the main deck. The distance forward of midships is shown positive. The distance aft of midships is shown negative (- sign).

2 The mean design location was calculated for both starboard and port side berthing conditions for all design ships except the AD-41.

3 The maximum service offset is the maximum distance of any service point of the design ships from the mean design location [illegible] excluding the AD-41).

Table 6-4. Location of Ships' Utilities Connections (Continued).

		COMPRESSED AIR					FUEL JP-5					FUEL F-76				
SHIP CLASS		AD-41	FF-1052	DD-963	CG-47	FFG-7	AD-41	FF-1052	DD-963	CG-47	FFG-7	AD-41	FF-1052	DD-963	CG-47	FFG-7
PORT SIDE	DECK NUMBER	3 4 4	-	01	-	02	01	01	-	01 01	02	01 01	01 01	01 01	01 01	02 02
	FRAME NUMBER	24 75 131	-	286	-	282	126	116	-	191 377	303	59 131	55 116	191 398	191 377	133 284
	DISTANCE FROM MIDSHIP (FEET) [1]	209 5 -219	-	-37	-	-93	-199	-52	-	60 -126	-114	70 -219	65 -70	55 -149	60 -126	56 35
	HEIGHT (FEET)	28 15 15	-	26	-	35	58	26	-	25 25	35	54 58	31 26	26 26	25 25	35 35
STARBOARD SIDE	DECK NUMBER	3 4 4	01	01	-	02	01	01	-	01 01	02	01 01	01 01	01 01	01 01	02 02
	FRAME NUMBER	24 77 139	91	286	-	282	126	109	-	191 377	303	59 131	55 109	184 398	191 377	133 284
	DISTANCE FROM MIDSHIP (FEET) [1]	209 -3 -215	-26	-37	-	-93	-199	-70	-	60 -126	-114	70 -219	65 -70	65 -149	50 -126	56 35
	HEIGHT (FEET)	28 15 15	25	26	-	35	58	26	-	25 25	35	54 58	31 26	26 26	25 25	35 35
MEAN DESIGN LOCATION (FEET) [2]		N/A	65				N/A	90				N/A	101			
MAXIMUM SERVICE OFFSET (FEET)		N/A	14				N/A	37				N/A	49			

GENERAL NOTE: The DDG-51 is excluded from the table due to preliminary nature of planning data.

NOTES: 1 The midship point is taken as one-half of the ship's total length along the main deck. The distance forward of midships is shown positive. The distance aft of midships is shown negative (- sign).

2 The mean design location was calculated for both starboard and port side berthing conditions for all design ships except the AD-41.

3 The maximum service offset is the maximum distance of any service point of the design ships from the mean design location excluding the AD-41.

Table 6-5. Mean Location of Services on the Pier.

SERVICE	DUAL LOCATION-FORE AND AFT OF AMIDSHIPS
Electrical	25 feet
Steam	62
Potable Water	52
Saltwater	72
Sewage	73
Oily Waste	41
Compressed Air	65
Fuel JP-5	90
Fuel F-76	101

With the ship berthed amidship to center of berth, port or starboard, and with the service outlets positioned at the mean locations:

- The maximum offset for electrical will be 20 feet; 50% will be within 10 feet.
- 50% of the steam offsets will be within 20 feet; 90% will be within 40 feet. The longest offset will be 50 feet.
- 50% of the potable water offsets will be less than 30 feet; all will be within 50 feet.
- 75% of the salt water offsets will be within 20 feet; all will be within 50 feet.
- 65% of the sewage line offsets will be less than 40 feet; the longest will be 55 feet.
- 75% of the oily waste line offsets will be within 20 feet; none will exceed 40 feet.

- 80% of the compressed air line offsets will be within 30 feet; none will exceed 40 feet.
- 60% of the JP-5 fuel offsets will be within 30 feet; all will be within 40 feet.
- 60% of the F-76 fuel offsets will be within 40 feet; all will be within 50 feet.

If the electric boilers are installed in the DD-963 class ships, additional electrical mounds will be required 200 feet fore and aft of the center of the berth in order to deliver the 2800 amps planned. These mounds would be used to support the electric boilers only.

6.3 Utility Gallery

Major design concepts are available for utility galleries that will alleviate a major portion of the congestion and work stoppages frequently associated with today's piers. The main objectives of the gallery concept was to:

- Reduce congestion on the main deck.
- Improve efficiency of all pier operations.
- Reduce manpower requirements for connecting or disconnecting cables and hose.
- Protect cables and hoses.
- Provide storage on the pier for cables and hoses.

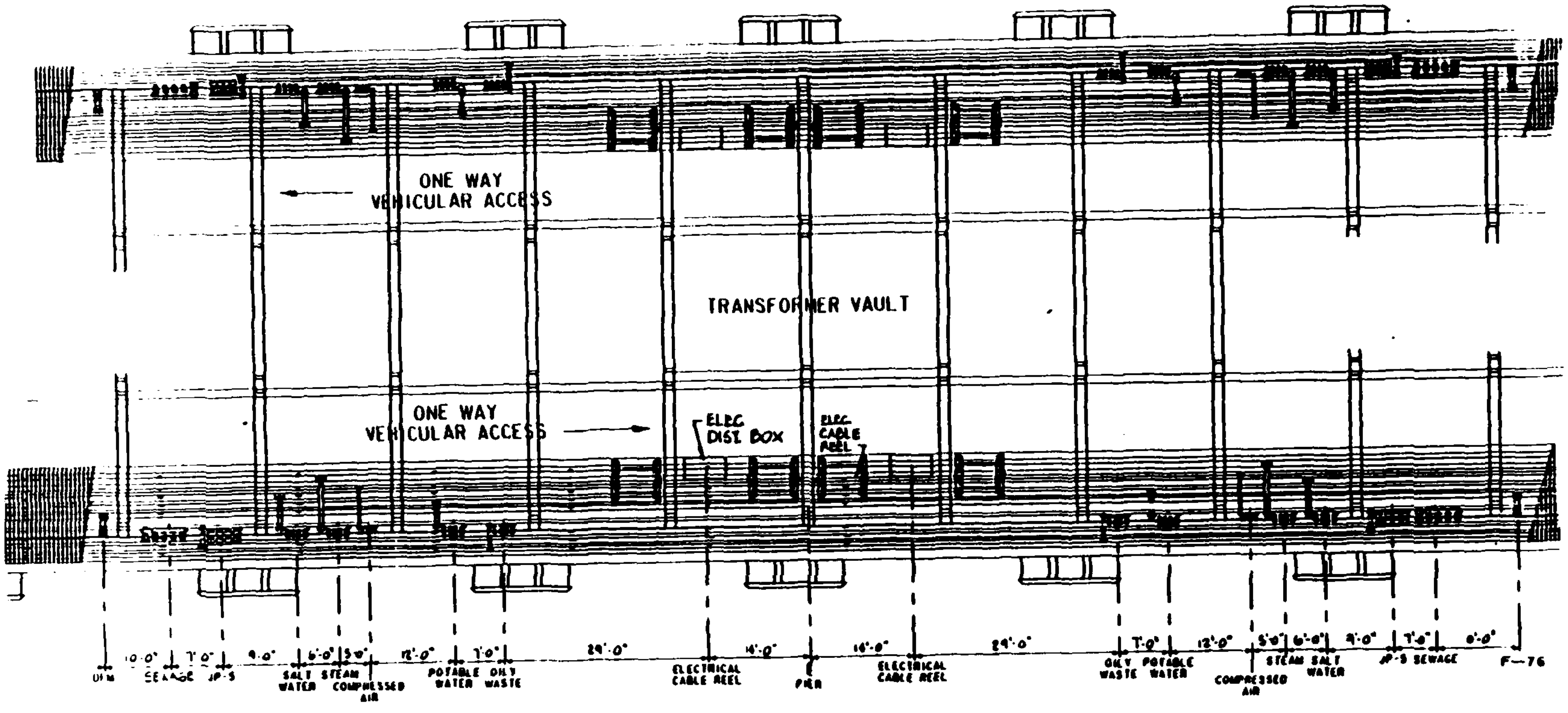
The gallery design concepts for both the pile-supported pier and floating pier are similar in layout and configuration. Both are based upon locating the electrical services at the center of the berth. This requires proper positioning of the ship, amidship to center of berth, as discussed under section 6.2.

The basic storage concept for electrical cables was a driving factor in the utility gallery concept. In this text, motorized reels are shown, although other approaches could be used.

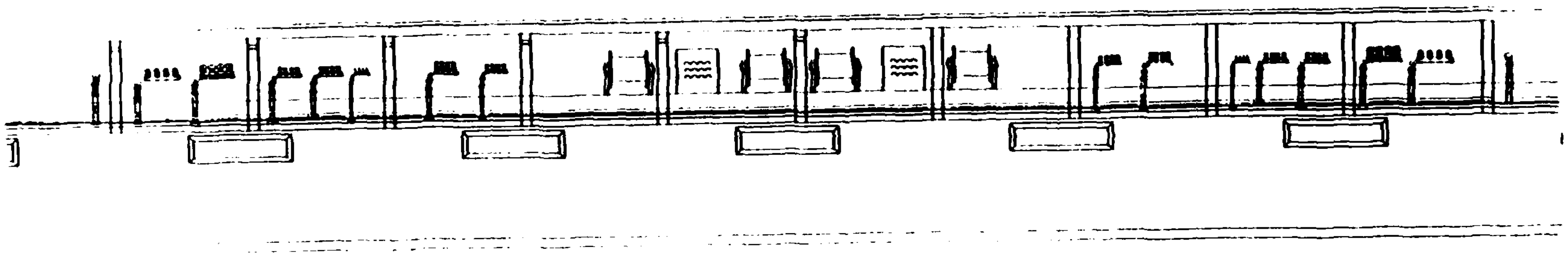
With the electrical mounds located near the center of the berth, the mechanical systems are positioned fore and aft basically in accordance with the optimum service locations outlined in section 6.2. Figure 6-5 shows a typical utilities layout at a berth for the floating pier. The layout for a berth on a pile-supported pier would be similar.

6.3.1 Pile-Supported Pier. The basic gallery section for the pile-supported pier was governed by the dimensional requirements of the pipe chase and by Occupational Health and Safety Administration (OSHA) clearance requirements. This design concept, shown in figure 6-6, shows the required vertical clearance of 7 feet 6 inches to the bottom of the upper deck and 6 feet 8 inches to the bottom of a projecting beam. The pipeway width is 11 feet 6 inches. A 5-1/2 to 6-foot diameter reel can be adequately accommodated. The roadway section is 11 feet wide and provides 10 feet 2 inches vertically which is adequate for the needed service vehicles. Removal of the reels will be by use of overhead crane rails and chain hoists to simple carts designed to accommodate the reels.

The pipeway is 3 feet 6 inches deep. Together with the OSHA vertical clearance requirements, this establishes a minimum total interior vertical dimension in the gallery of 11 feet. This may result in a rather low elevation for the lower deck if the upper deck elevation is to be maintained at elevation of +20 feet. In certain geographical areas having rather high normal daily tides, a restriction of the permissible design or construction options to accommodate the higher tides during the construction of the pile-supported pier concept may result. Either the interior gallery dimensions or the upper deck



PLAN VIEW



SIDE ELEVATION VIEW

Figure 6-5. Utilities Layout, Floating Pier

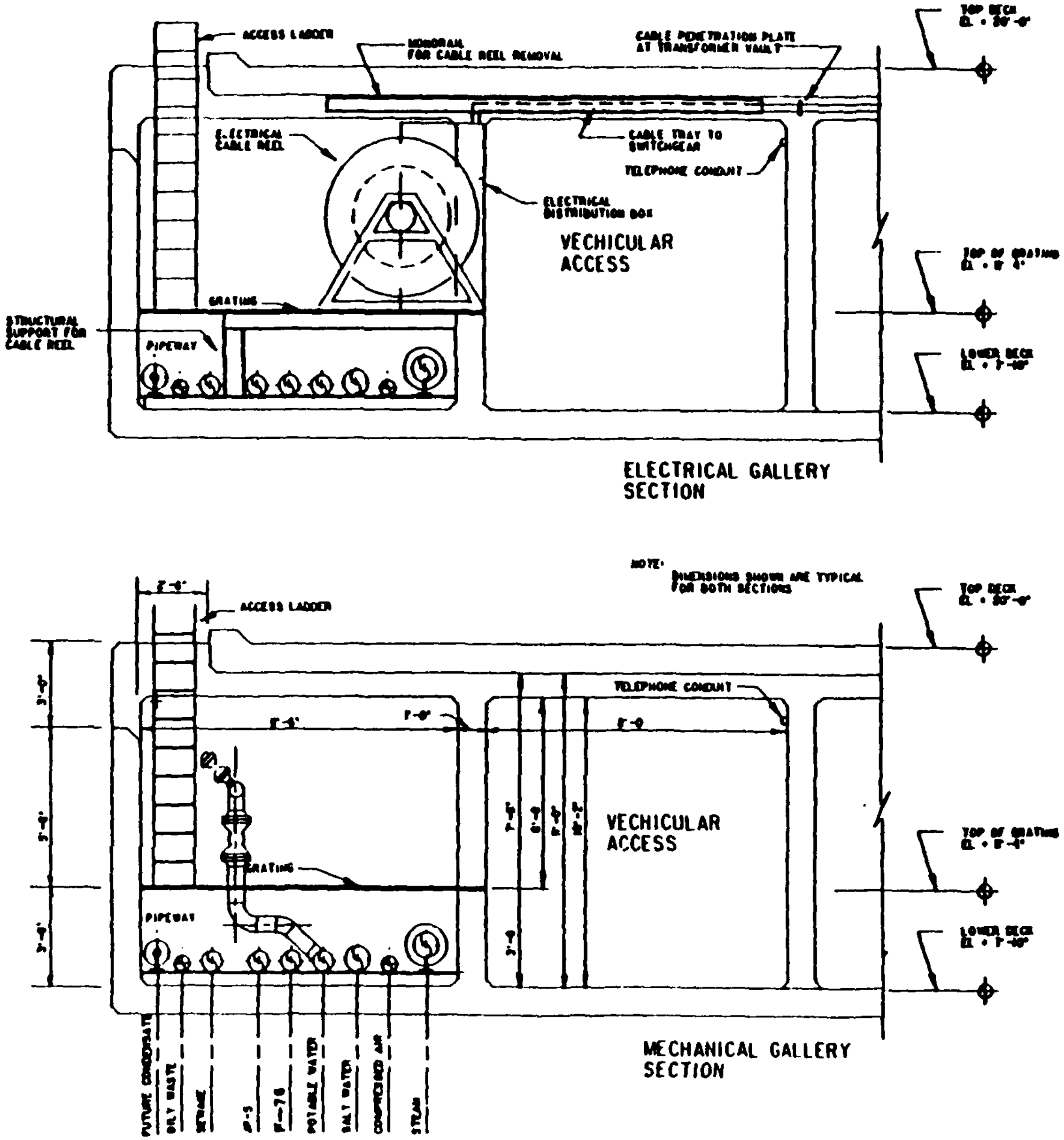


Figure 6-6. Utility Gallery, Pile-Supported Pier

elevation may require adjustment to meet the restrictions caused by the combination of structural element sizes and higher normal tides.

To avoid some of these constraints in such areas, an alternate concept was developed for the pile-supported pier which raises all of the above elevations by one foot. This is shown in the pile-supported pier alternate concept shown in figure 6-7. The reduction of the inside dimension by one foot is accomplished by eliminating the lateral piping runs to serve the mechanical stations located along the outboard wall and by establishing the station manifolds directly above the feeding service line in the pipeway, as shown in figure 6-8. This reduces the vertical dimension of the pipeway from 3 feet 6 inches in the base concept shown in figure 6-6, to 2 feet 6 inches in the alternate concept shown in figure 6-7. Aside from this change and the change in the locations of the mechanical manifolds, the recommended and alternate concepts are the same.

All of the elevations shown are based upon 1-foot thick slabs, upper and lower deck, plus a 10-inch dropped beam in the upper deck, and the bottom of the lower slab being at an elevation of +7.0 feet. The actual elevations of the lower members can only be determined during the design of a specific pier project since the final structural element sizes may be affected by such variables as pile bent spacing, deck loading, seismic loading, fender and bollards loading, the structural framing methods selected, and basic choice of precast versus cast-in-place construction. Variations in the gallery dimensions and elevations of a pile-supported pier may be inevitable.

The elevations of all bottom members may, of course, be altered by raising the elevation of the upper deck above elevation +20 feet.

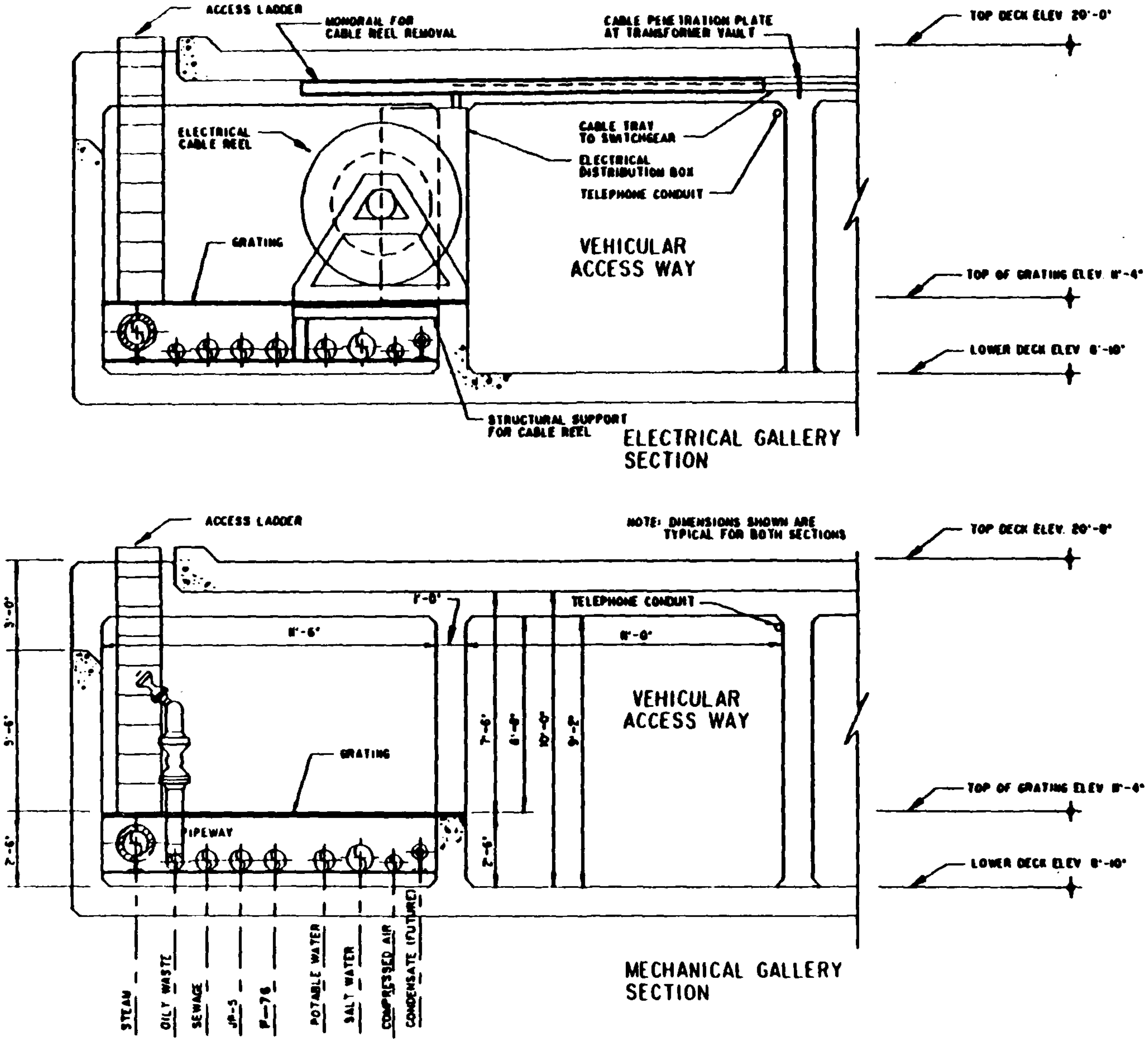


Figure 6-7. Alternate Utility Gallery, Pile-Supported Pier

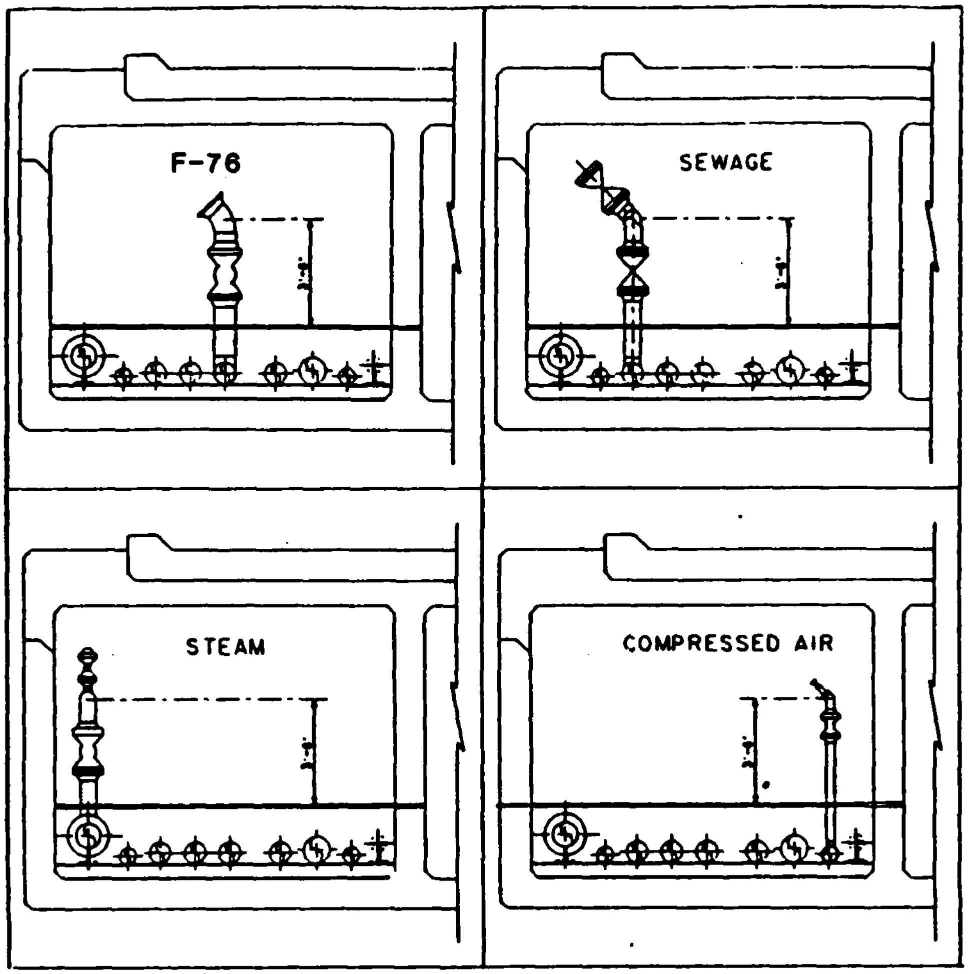


Figure 6-8. Sections, Alternate Utility Gallery, Pile-Supported Pier

6.3.2 Floating Pier. The gallery section concept for the floating pier is similar to the concept for the pile-supported pier. Figure 6-9 shows typical sections.

The main difference between the utility gallery in the floating pier and pile-supported pier is in the vertical clearance and width of pipeway. The floating pier provides 10 foot unrestricted clearance between grating and beam, while the pile-supported pier restricts clearance to 6 foot 8 inches.

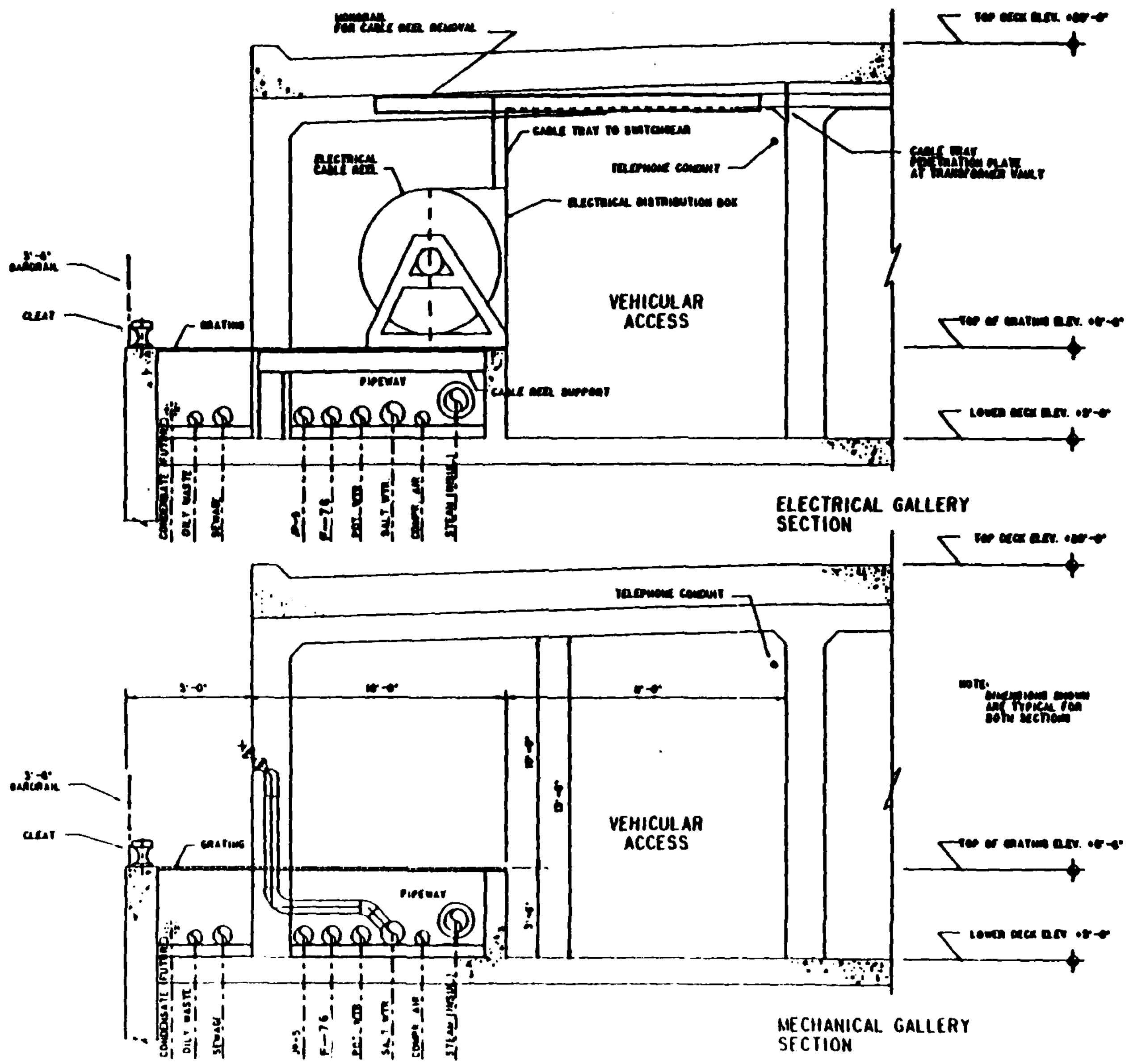


Figure 6-9. Utility Gallery, Floating Pier.

Unlike the pile-supported pier, the floating pier is not constrained by problems associated with tides. The width of the pipeway is 13 feet 6 inches.

6.3.3 Gallery Drainage. Removal of rain water, washdown water, and waste liquids that spill or accumulate in the gallery is to be accomplished by sloping the lower deck under the pipeway to a series of sumps, where permanently-installed sump pumps pick up the oily or contaminated water and discharge it into the oily waste main.

6.3.4 Utility Gallery Operations. A basic evaluation was made at two main naval installations comparing standard operations observed on the existing piers with estimated comparable operations that would be anticipated to exist on an optimumly designed pier to support the same type of ship. The evaluation of existing operations was a function of averaging the various operations observed for the same type of ship and deducting for lost time which was not a function of the operation. The evaluation of the optimum pier support operations was a function of observing operations where all utilities were positioned on the pier in advance, interviews with utilities management personnel, judgment in developing estimates, and analysis of data. Electing to use a double-deck pier, with the outboard areas of the lower deck dedicated to servicing and storing utilities hoses and cables, would provide pier characteristics that could produce major savings in manning, time, labor man-hours, and equipment requirements to hookup and disconnect ships, plus extend the life expectancy of cables and hoses significantly. Potential savings could amount to:

Element	Savings
Manning Level (Men)	20 - 45%
Operational Time (Hours/Minutes)	15 - 75%

Element	Savings
Manpower (Man-hours)	25 - 65%
Equipment (Operating Hours)	10 - 20%
Power Cable Replacement	50 - 75%
Steam Hose Replacement	50%
Fresh Water Hose Replacement	50%
CHT Hose Replacement	50%
Plug Replacement	50 - 80%
Connector Replacement	10 - 65%

6.4 Pier Electrical Distribution System

Several improvements either have been or are being made to the pier electrical distribution system designs and procedures in order to improve upon the quality and quantity of electrical power and the methods of providing service to the ships. These improvements include:

a. The introduction of the double-deck pier and utility gallery concepts allowing much greater flexibility and accessability in installing and maintaining primary and secondary distribution systems, transformer vaults, switchgear, service mounds, and cable assemblies.

b. Recently developed cable handling equipment which drastically reduces the time and manpower required to service the ships.

6.4.1 Primary Feeders, Transformers, and Switchgear. The newest conceptual designs with the double-deck pier, provide for the primary feeders to be installed on the pier under the main deck in suspended conduit. The primary distribution system is designed as a loop system, providing complete redundancy to each transformer station. Some of the latest designs are also planning for electrical power to be provided to a Med-mooring at the end of the pier.

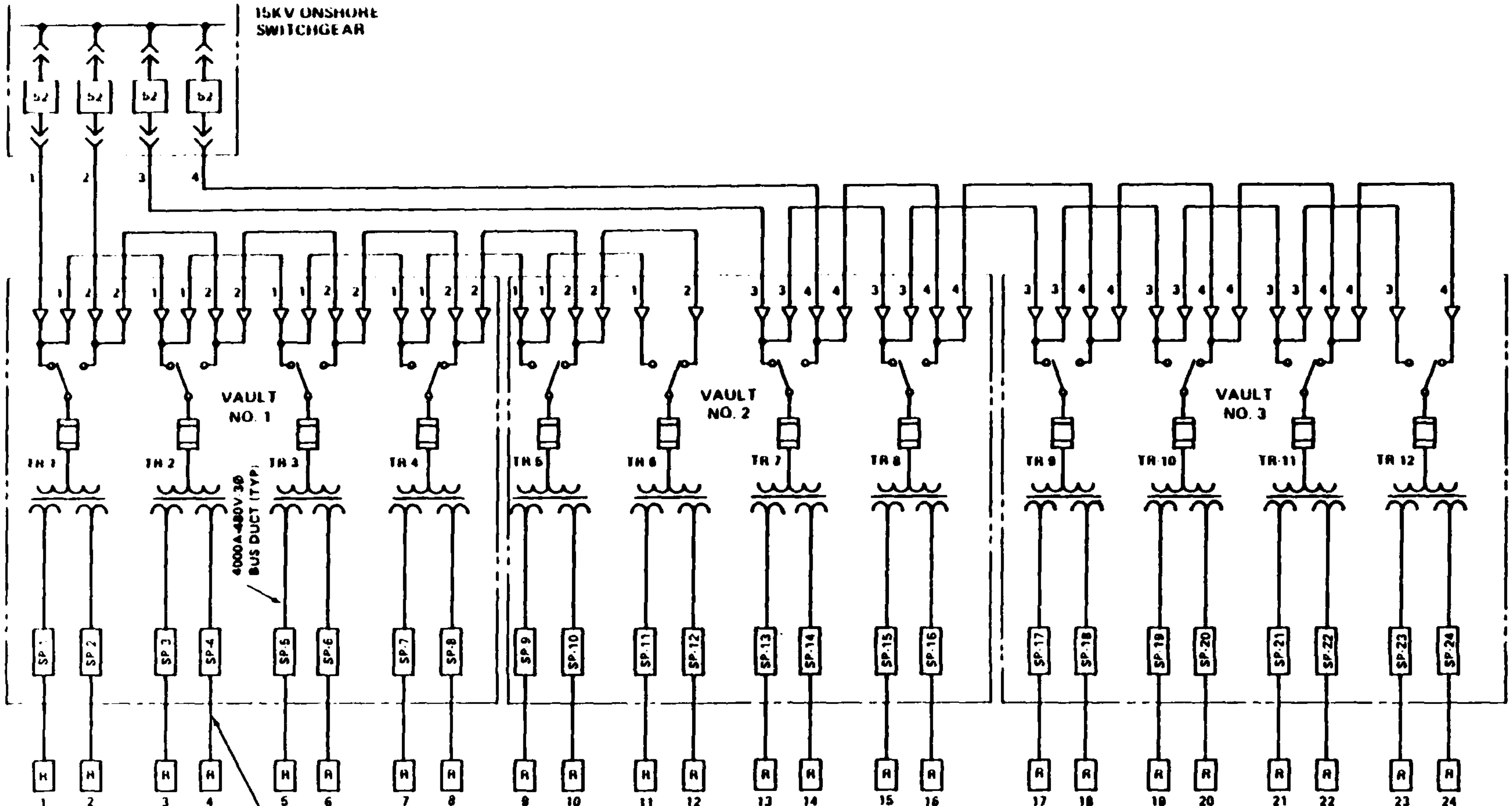
6.4.1.1 Distribution Substations. Using, in this case, a typical pier design concept to support four small and medium surface combatant berths, plus a Med-moor at the seaward end of the pier, 12 substations would be required to be located in three electrical equipment vaults on the pier's lower deck. Each substation would be rated 3750/5250 KVA. For the four berths pierside, each transformer would service one ship at full connected load or more than one ship at reduced load. For the Med-moor, the 4 substations would service the destroyer tender and the destroyers under repair. Vaults would be located in the center of the pier as shown in figure 6-5. Each of the distribution substations would consist of a transformer with high-voltage incoming line switching, protective devices and outgoing low-voltage distribution switchgear as shown in figure 6-10.

The distribution substation for the proposed double-deck pier configuration would be completely enclosed in a concrete vault or a concrete vault lower section extending below the second deck and self-supporting sheet steel structure of drip proof construction, covering the upper section. In either design, access into the vault would be provided from the lower deck to perform maintenance and remove small pieces of equipment from the vault. The main access to remove or install large equipment would be through the main deck of the pier.

The enclosure would house the following components:

- Load Interrupter Switch

  The load interrupter switch connects the two incoming primary feeder circuits to the transformer through the primary fuses. The switch consisting of a liquid-filled, 3-phase, 3-position (Feeder A, Open, Feeder B) load interrupter switch with provisions for locking in the "open" position, disconnects the transformer primary fuses from the incoming feeder circuits. The



NOTE

1 PRIMARY SWITCHES ARE SHOWN IN THEIR NORMAL OPERATING POSITION

2 FAULT DUTY AT EACH RECEPTACLE PANEL IS RATED 90,000 AMPS

LEGEND

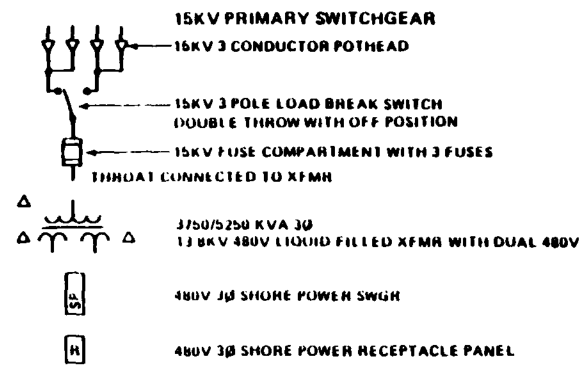


Figure 6-10. Electrical One-Line Diagram, Four Berths Plus a Mediterranean Mooring.

switch is manually operated and provided with compound-filled terminal changers for the four cables, two from each feeder circuit.

- <u>Primary Fuses</u>

  The primary current-limiting fuses are housed in an isolated compartment of the incoming line section. The compartment access door is interlocked to allow opening only when the load interrupter switch is in the "Open" position.

- <u>Transformer</u>

  The liquid-filled transformer converts the distribution voltage to utilization voltage. The transformer tank, of welded steel plate, would be equipped with a pressure relief fitting and a temperature alarm. Radiators, welded directly to the tank, are equipped with forced air cooling fans for use when additional cooling is required. Polychlorinated biphenyls (PCBs) should not be used as insulating oils in pier transformers. Secondary containment should be provided to prevent leakage of insulating oils.

- <u>Bus Duct</u>

  Metal-clad bus ducting is used to connect the distribution transformer's two secondaries and the two outgoing low-voltage switchgear. The bus duct is nonsegregated, phase-type design with the bus rated at 600 volts, 4,000 amps continuous. Fault duty at the receptacle panel is rated 90,000 amperes.

- <u>Outgoing Low Voltage Switchgear</u>

  The switchgear units consists of completely enclosed, self-supporting sheet steel unitized structures. The enclosure incorporates individual circuit breaker and instrument compartments. The switchgear is of drip-proof construction suitable for below-deck service. This equipment comprises the 480-volt shore power distribution switchgear and incorporates the metering and protective devices for the transformer secondary and the cable feeder circuit breakers for the shore power receptacle panel. The switchgear has a 480 volt, 3-phase, 60 Hz bus rated 4,000 amperes supplied through a 4,000-ampere main circuit breaker. Branch circuit breakers rated 400 amperes are provided to feed the 10 receptacles in the shore power receptacle panel. Fault duty at the receptacle panel is rated 90,000 amperes. All circuit breakers are the electrically operated, drawout type with integral current limiting fuses.

6.4.1.2 <u>Distribution Feeders</u>. Power distribution would be provided by cables conforming to the following description:

a. <u>15,000 Volt Class Power Cable, UL Type MV-90</u>

   Ungrounded neutral (133 percent voltage level insulation).

   - <u>Service: Primary Power to Pier</u>

     This cable would supply the primary power from shore based switchgear to the pier's primary switchgear housed in the electrical equipment vaults located on the lower deck of the pier. The cables are installed in polyvinyl chloride (PVC)

coated, galvanized-steel conduits (or equal) routed below the pier's upper deck. The cable construction is three conductor, 350 mcm, copper-stranded conducters individually covered with semiconducting tape, neoprene insulation, semiconducting film
and copper-shielding tape intercalated with color-coded tape; cabled together with fillers and a stranded-copper, uninsulated ground wire in one interstice, assembly core covered with tape and cross-linked polyethylene jacket overall. It is rated for 90° C conductor temperature.

b. 600 Volt Class, UL Type MC (XHHW or Equal)

- Service: Shore Power Feeder Circuits

This cable connects the shore power distribution panels at the pier side to the switchgear housed in the electrical equipment vaults. The construction is three conductor, copper 500 mcm, Class B stranded per ASTM B-8, with cross-linked polyethylene insulation. Individual conductors are cabled together with nonhydroscopic fillers and a binder tape overall. An impervious, continuous, corrugated aluminum sheath is provided. The jacket is extruded PVC (black). This is also rated for 90°C conductor temperature.

c. 600 Volt Class, Power and Lighting, Flexing Service

- Service: Pier-to-Shore Flexible Shore Power Cable

This cable is used to connect the ship's electrical systems to the pier's power supply via the shore power receptacle panels at the pier side. Its construction consists of three conductors, 500 mcm, extra-flexible copper conductors with

polychloroprene insulation. Individual conductors are cabled together with fibrous fillers and suitable binder tape overall. The jacket is extruded polychloroprene (black). The cable is rated for 50°C conductor temperature. Construction is in accordance with MIL-915E/6 (NAVSEA).

d. 600 Volt General Wire

- All conductors used in the low-voltage electrical systems for power, control, and lighting are as follows. The conductor is compressed, concentrically, stranded, uncoated soft copper insulated with extruded black, cross-linked polyethylene - XLP, UL listed as Type XHHW, rated 600 volts. The minimum wire size used is #14 AWG. All wire is single or multi-conductor cable to be installed in conduit. It is rated at 600 volts with a maximum conductor temperature of 90°C in dry locations and 75°C in wet locations. Because of its reduced insulation wall thickness, Type XHHW affords a more efficient conduit fill than comparable insulations such as Type TW.

6.4.1.3 Conduit. All conduit will be provided in accordance with the following descriptions.

a. Rigid

Rigid metal conduit will be used as the raceway for lighting, pier electrical services, communications and the incoming electrical service to the pier. It is galvanized rigid steel with a 40 mil PVC bonded coating. Conduit fittings are cast ferro-alloy or steel with a similar PVC bonded coating. In general, conduit will be routed in close proximity to and supported from the underside of the upper deck.

b. Flexible

Flexible sections in the conduit system will be achieved by utilizing liquidtight, flexible metal conduit. These flexible portions of the conduit system are required on the ramp at its connection points to the pier and the shore. Other uses are at the conduit connections to the electric motors. The construction will consist of a flexible, interlocked metal conduit with an outer liquidtight PVC jacket as shown in figure 6-11.

6.4.1.4 Cable Trays. Cable trays are installed below, and supported from the underside of, the upper deck of the pier. These trays are utilized for routing the shore power feeder circuit cables from the switchgear in the electrical equipment vaults to the shore power receptacle panels installed on the lower deck at the pier sides.

All cable tray construction is a composite of polyester resin and fiberglass reinforcing to provide a corrosion-resistant and fire-retardant raceway. Connecting hardware is 316 stainless steel. The cable tray is the ladder type with rungs spaced at 12-inch or 18-inch intervals. Side rails are channel structural shapes. The tray system conforms to the applicable sections of the National Electrical Code, Standard VE1 and ASTM E-84 (Class 1 rating).

6.4.1.5 Pier Service and Motor Control Centers. This equipment is located in the electrical equipment vaults and includes motor starters, branch circuit breakers, industrial services, lighting and power transformers, and lighting and power panels, for the pier electrical services and equipment.

Power is provided from the secondary 4000 amp, 480 volt, 3-phase, 60 Hz bus ducts servicing the shorepower switchgear. Dual feeders are provided to each pier service and motor control center through 600-amp circuit breakers. Selection of the feeder is made through an automatic transfer switch.

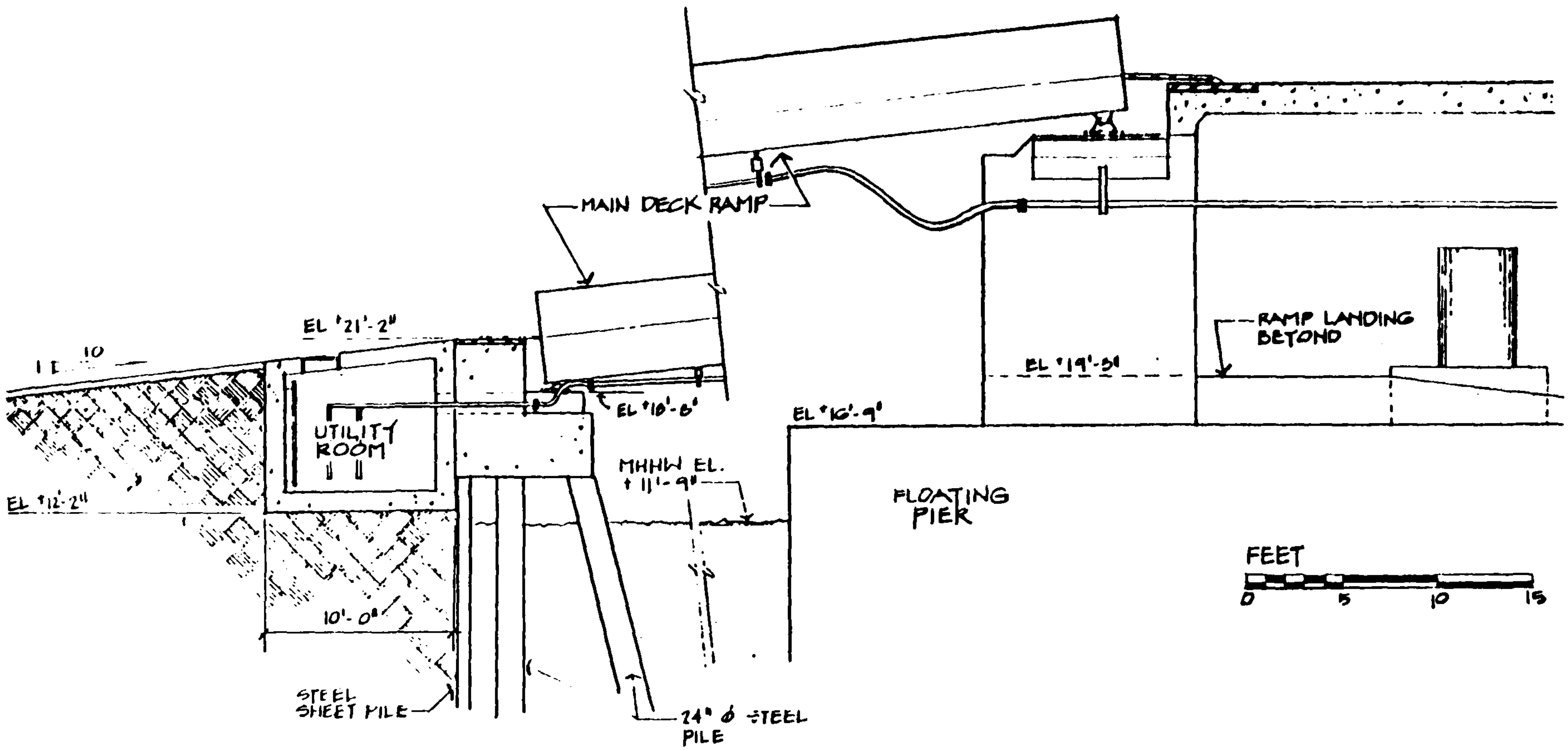


Figure 6-11. Electrical Connections at Ramp for a Floating Pier.

The pier service and motor control center is a floor-mounted assembly of enclosed vertical sections containing combination motor control units and branch circuit breakers. The complete assembly is NEMA 2, drip-proof, indoor classification. All circuit breakers are externally operable, plug-in type with integral current limiters. Motor starter units are plug-in assemblies consisting of circuit breakers, motor starters and control power transformers.

Small service transformers are provided for the power panels, converting the 480-volt secondary to the utilization voltage required to provide the pier services; i.e. lighting, fans, sump pumps, receptacles, etc.

6.4.2 Service Centers. Electrical power for the berthed ships is provided by receptacle panels located on the lower deck at the center of each berth on both sides and if a Med-moor is used, at the sea end of the pier. Additional auxiliary receptacle panels will be required 200 feet fore and aft of the berth center to support the planned DD-963 electric boiler installation. The main panels contain 10 switches and interlocked receptacles which are connected by cable from a branch circuit breaker in the switchgear located in an ele trical equipment vault. The auxiliary panels will contain seven switches and receptacles. In all cases, each receptacle can be controlled from the panel.

6.4.2.1 Receptacle Panel. The receptacle panel is a freestanding, weather-proof enclosure constructed of galvanized steel plate. Weathertight receptacles are flush mounted on the front of the panel. Weatherproof control switches and indicating lights for each receptacle are located on the front of the panel. From these receptacle panels or mounds, 480 volt, 3-phase, 60 Hz ac electrical shore power is distributed by portable, flexible power cables to the berthed ship's shore power connection panel. Figure 6-12 provides a typical panel one-line diagram.

6.4.2.2 Reels. The pier-to-ship portable electrical cables can be stored in various configurations on the lower deck of the double deck pier. Of the different concepts evaluated, the fixed reel offered the greatest capacity, fastest play-out and retrieval, and conflicts the least with the other intended uses of the utility gallery. Figures 6-6, 6-7, and 6-9 show the position of the fixed reel within the utility gallery for various pier designs.

The cable reels of the specific type used in this application have not as yet been manufactured. However, all of the features comprising the reels have been designed tested and applied separately or in combinations on other reels currently in service. The major features of the reels include:

- Each reel is freestanding with provisions for securing the reel

  base to the pier deck. The concept proposes four reels. Two reels could contain 125-foot or longer lengths, and two could contain 50-to-100-foot lengths. Field testing may be needed to establish effective lengths to be used. With modest changes in reel width, large variations in capacity are possible.
- Certain auxiliary facilities will be required for removal of reels for cable replacement or maintenance. Two short overhead transverse rails are provided for each reel as shown in figures 6-6, 6-7 and 6-9. Two removable chain hoists will be used to lift the reel and move it over to the vehicular accessway for removal by a cart or trailer.

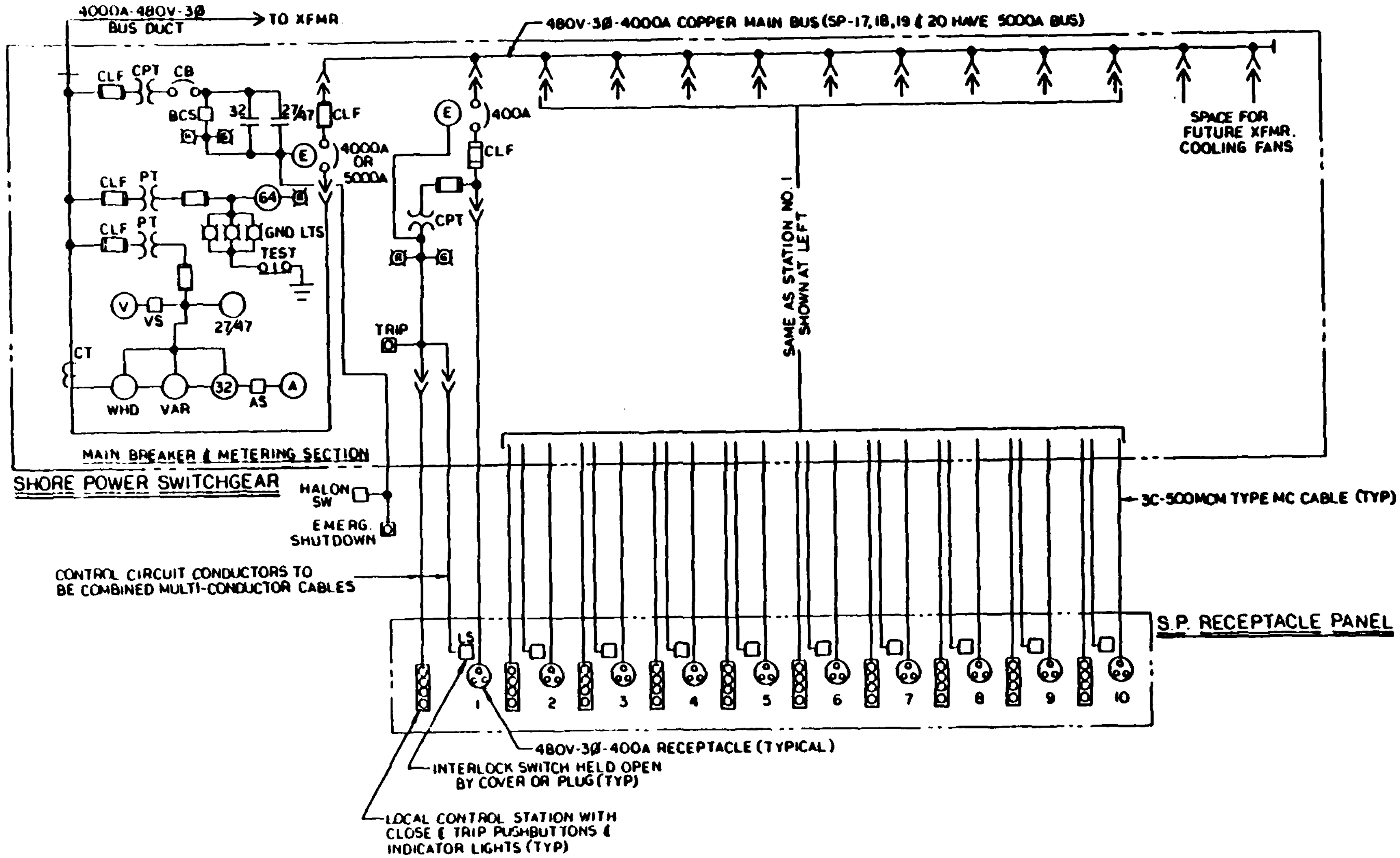


Figure 6-12. Typical Electrical Shore Power Switchgear and Receptacle Panel

- Materials of construction must recognize that the reels will be located in a damp environment. If dissimilar metals are employed, their relative positions in the galvanic series should be considered. If the support framework and the motor, gear drive mechanism, and bearings are all steel, consideration should be given to retaining steel as the material for the reels.
- The reels are designed to minimize manpower requirements for cable storage and retrieval and to expedite the time required for hooking up and disconnecting the cables from pier to the ship. The employment of a mobile, powered, articulated boom is planned on the main deck. It will utilize one operator and one helper. The powered boom will be equipped with cable handling hooks, rollers, slings and guides to handle one 3 conductor cable at a time. A two man crew will operate the reel on the lower deck.
- The reel drum design shall be dependent upon the storage requirements. The continued use of existing portable power cables and Viking (or similar) plugs are also anticipated. Since it is expected that the reels will utilize random wind rather than level wind, an allowance of 10% for the additional capacity required for random wind is needed. In addition, since the terminators are expected to be wound on the reel, an additional 10% allowance is also made. Table 6-6 provides estimated capacities for different reel designs.
- The drum shaft is powered from a reversible pneumatic motor through an adjustable friction clutch.
- A cable guide, or fairleader, is used to aid in aligning the cable during reeling and unreeling.

Table 6-6. Reel Capacities and Weights.

(BASED ON 3.5-FOOT-DIAMETER DRUMS)

FLANGE DIAMETER IN FEET	REEL WIDTH IN FEET	REEL CAPACITIES		CABLE AND REEL ASSEMBLY WEIGHTS	
		TOTAL CAPACITY[1]	ESTIMATED DESIGN CAPACITY[2]	CABLE WEIGHT IN TONS[3]	CABLE AND REEL WEIGHT IN TONS[4]
5	5	801	641	2.46	3.3
	5½	881	705	2.70	3.6
	6	961	769	2.95	3.9
	6½	1041	833	3.19	4.3
5½	5	1131	905	3.47	4.6
	5½	1244	995	3.81	5.1
	6	1357	1086	4.16	5.5
	6½	1470	1176	4.50	6.0
6	5	1492	1194	4.57	6.1
	5½	1641	1313	5.03	6.7
	6	1791	1433	5.49	7.3
	6½	1940	1552	5.94	7.9
6½	5	1885	1508	5.78	7.7
	5½	2073	1659	6.35	8.5
	6	2262	1810	6.93	9.2
	6½	2450	1960	7.51	10.0

[1] Total theoretical capacity (100%) is based on level wind.

[2] Estimated design capacity is based on total capacity (100%) less 10% to allow for random wind, and less 10% to allow for cable terminators (total theoretical capacity - 20% = estimated design capacity).

[3] Cable weight is based on the estimated design capacity of the reel using 7660 pounds/1000 feet (estimated design capacity of reel x 7660 ÷ 1000 = cable weight in pounds).

[4] Cable and reel weight is based on cable weight plus 33% of the cable weight as an allowance for the weight of the reel assembly (cable weight + 33% of cable weight = cable and reel assembly weight).

6.4.3 Power Conditioning Equipment

The Navy is currently developing equipment technology using either automatic voltage regulators or high-speed switching transformers to control the distribution voltage of shore power being provided to Navy ships from Navy piers. The basic objective is to provide voltage regulation to meet the requirements for Type I electrical power specified in DOD-STD-1399. As the Navy's direct representative, NCEL is working with industry to develop the equipment using both state-of-the-art and futuristic concepts. A 2500 KVA developmental automatic voltage regulator (AVR) transformer is scheduled to begin a one year testing program at NAVSTA San Diego beginning in September 1985. Planned project output is scheduled for 1987.

While firm recommendations covering power conditioning are not planned prior to 1987, current shore facilities planning activities need to recognize the requirement for space to support the acquisition of voltage regulator equipment, as a part of any new pier designs or pier retrofit plan; and the actual space requirements could vary significantly. The near-term, automatic voltage regulator equipment will be far more space intensive than the more futuristic, high speed switching transformers. For comparison, the 2500 KVA AVR selected to be tested now measures approximately 6.5 feet x 9.5 feet x 11 feet high. The high-speed switching transformers, in contrast, will probably be packaged in a unit measuring only a few cubic feet in volume.

6.4.4 Power Cable Handling Equipment

NCEL has developed equipment for handling heavy (8 lb/ft) electrical shore power cables used for electrical support to berthed Navy vessels. The equipment consists of a commercial, truck-mounted hydraulic telescoping boom modified with specialized attachments for the application. The principal

component of the system is a commercially available, 360-degree-rotating, telescoping, hydraulic crane mounted on a 5-ton, conventional stake truck. The material-handling crane, commonly used in the construction and maintenance industries, was field-modified with special attachments to handle 3-inch diameter, THOF500, shore power cables. Materials for field modifications included hydraulic components such as control valves, actuators, hose reels, hoses, and accessories to provide power to a unique cable support/feed mechanism, called a power block.

Field testing of the cable handling systems consisted of rigging and unrigging 15 ship classes at the Naval Station Norfolk. Benefits derived included: (1) an average 40% time reduction to rig/unrig cables between pier and ship, (2) over 60% reduction in ships' personnel manhours required for cable rigging/unrigging, (3) a potential 30% increase in cable life (reduction in cable replacement costs) due to reduced wear and tear compared to current methods. Additional benefits observed were the improved appearance of piers because of the capability to remove unused cable quickly and improved public works response to fleet readiness needs.

Three cable/storage/transport techniques and their associated equipment were also tested to evaluate their effectiveness in the operating environment and their compatibility with the prototype cable-handling truck. The three storage/transport methods are as follows:

Technique	Equipment
Manual coiling	4-x-4-foot wooden pallets; 6,000-pound forklift
Reeling	Cable tensioning reel truck
Reeling	Trailer-mounted diesel-powered reel; tow vehicle

Of the three cable storage/transport techniques tested with the prototype cable-handling equipment, the technique of coiling cables on wooden pallets provided the greatest benefit to utility service operations on existing piers. The analysis identified the following operational benefits:

- minimum requirement for support equipment
- minimum cost to implement
- minimum storage area required
- minimum pier space required
- minimum time requirement to remove cables from berthed ships
- minimum time requirement to remove unused cables from piers
- maximum ability to inspect or maintain cables
- cables easier to handle in shorter 125-foot lengths

The disadvantage of the coiling technique versus reeling equipment is a slight increase (<5%) in the time and labor from PWC to complete a cable-handling evolution (from storage to service on a ship and back to storage).

A User Data Package containing planning, acquisition, and implementation documentation for the Shore-to-Ship Electrical Power Cable Handling Equipment, has been distributed by NCEL.

6.5 Pier Mechanical Sytems

Several improvements have been made in pier mechanical support systems as a result of the introduction of the double-deck pier and utility gallery designs, and work being performed to improve steam purity.

6.5.1 Distribution Systems. The proposed design of the mechanical systems in a double-deck pier configuration establishes a minimum number of service points, maximizes their location convenience, improves upon accessability for operations and maintenance, protects hardware, and provides flexible expansion capabilities.

a. Pipeway.

Eight required mechanical services and one future service were considered in the design of the pipeway in the utility gallery. Piping requirements for these services are shown in table 6-7. All utility piping headers would be routed within a 11.5 foot wide by 3.5-foot deep pipeway for the pile-supported pier, as shown in figures 6-6 or 6-7, or a 13.5 foot wide by 3.5 foot deep pipeway for the floating pier as shown in figure 6-9. Piping would be suspended on 6-inch steel I-beams placed transversely across the pipeway. The I-beams would be placed directly on the lower deck.

All services, including sewage and oily waste collection lines, are looped. The lines are also recommended to be equipped with sectionalizing or isolation valves. This allows repairs or expansion to be accomplished without a complete system shutdown and provides the hydraulic advantage of a looped system.

The location pattern of the mains within the pipeway may be somewhat random, except that the large-diameter steam line should be located as far as possible within the pipeway from the hose station, to allow maximum flexibility of the laterial connections. The location of the sanitary sewage and oily waste lines at the outer edge of the lower deck would provide the pier designer the option of utilizing gravity flow to nearby lift stations if pressure mains are not used. Room is also available for other small lines for future services such as oxygen and acetylene or MAPP gas for expanded maintenance requirements, or demineralized water for make up to shipboard steam generation systems.

Table 6-7. Distribution Lines, Mechanical Services.

SERVICE	LINE SIZE
150 psi Dry and Saturated Steam	10-inch-diameter
60 psi Potable Water	8-inch-diameter
150 psi Salt Water	10-inch-diameter
Fuel, F-76	8-inch-diameter
Fuel, JP5	8-inch-diameter
Compressed Air	6-inch-diameter
Compressed Air	6-inch-diameter
Sanitary Sewage	8-inch-diameter
Ship's Oily Waste	6-inch-diameter
Clear Condensate Return	(Future space provision only)

The laterals are above and perpendicular to the mains for the conventional pile-supported pier and floating pier as shown in figure 6-13. The hose stations line up in each of these concepts under the access opening.

The pipe should be of ASTM A106-B or API5L-B, carbon steel with 150 pounds ANSI flange ratings, Schedule 40 or 80 seamless pipe walls. Valves would be flanged. Piping would be of random length, butt welded, sand blasted, primed and painted.

For the floating pier, all piping systems except the fire main, would be shore connected via flexible connectors, or swivel connectors, at the ramp similar to that shown in figure 6-14. The fire main would be self-contained on the pier requiring no shore-to-pier connection.

b. Compressed Air

A 6-inch header is recommended with 3-inch station risers to manifolds serving four hose connections as shown in figure 6-15. These stations

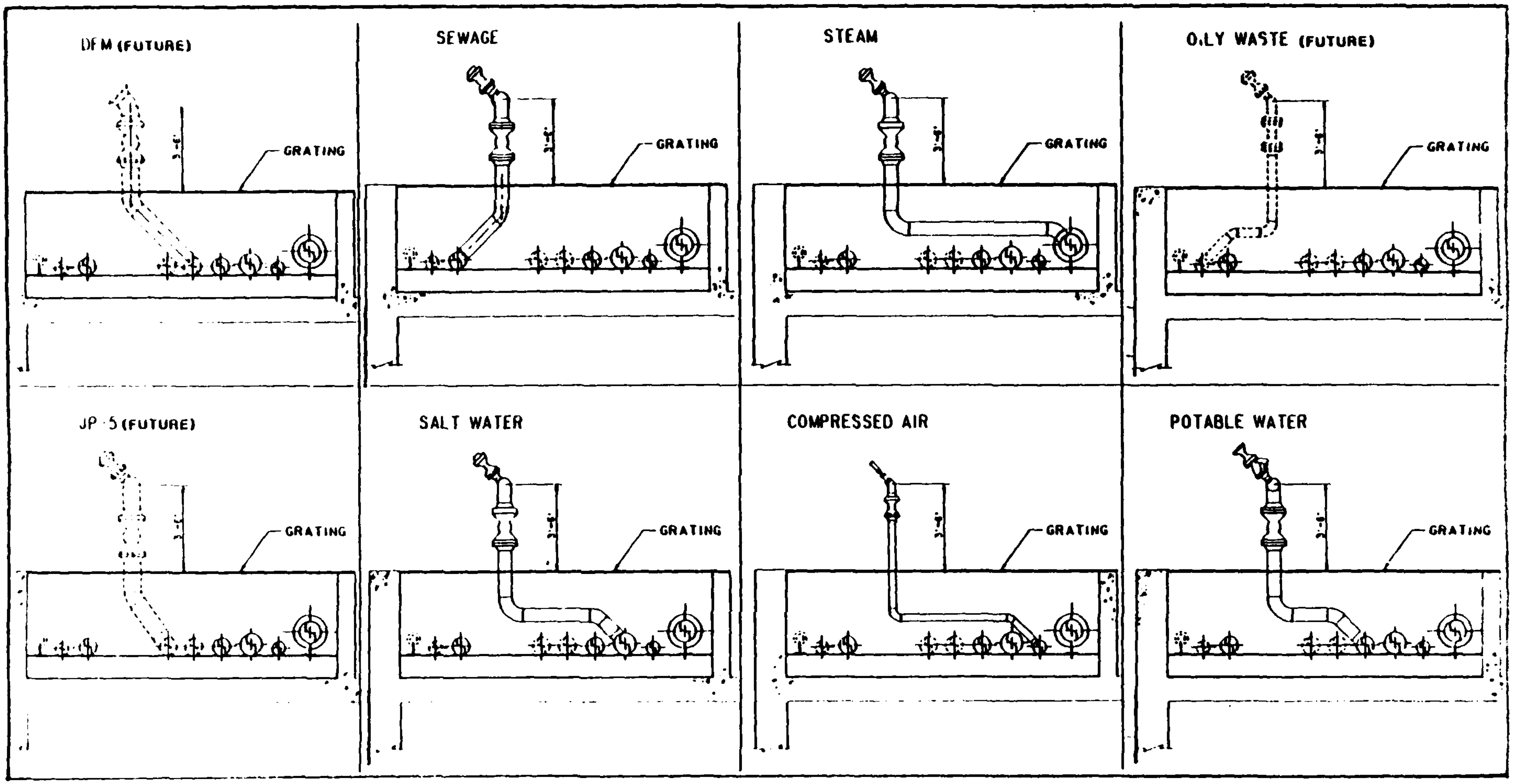


Figure 6-13. Sections, Mechanical Laterals, Utility Gallery, Typical for Pile-Supported or Floating Pier.

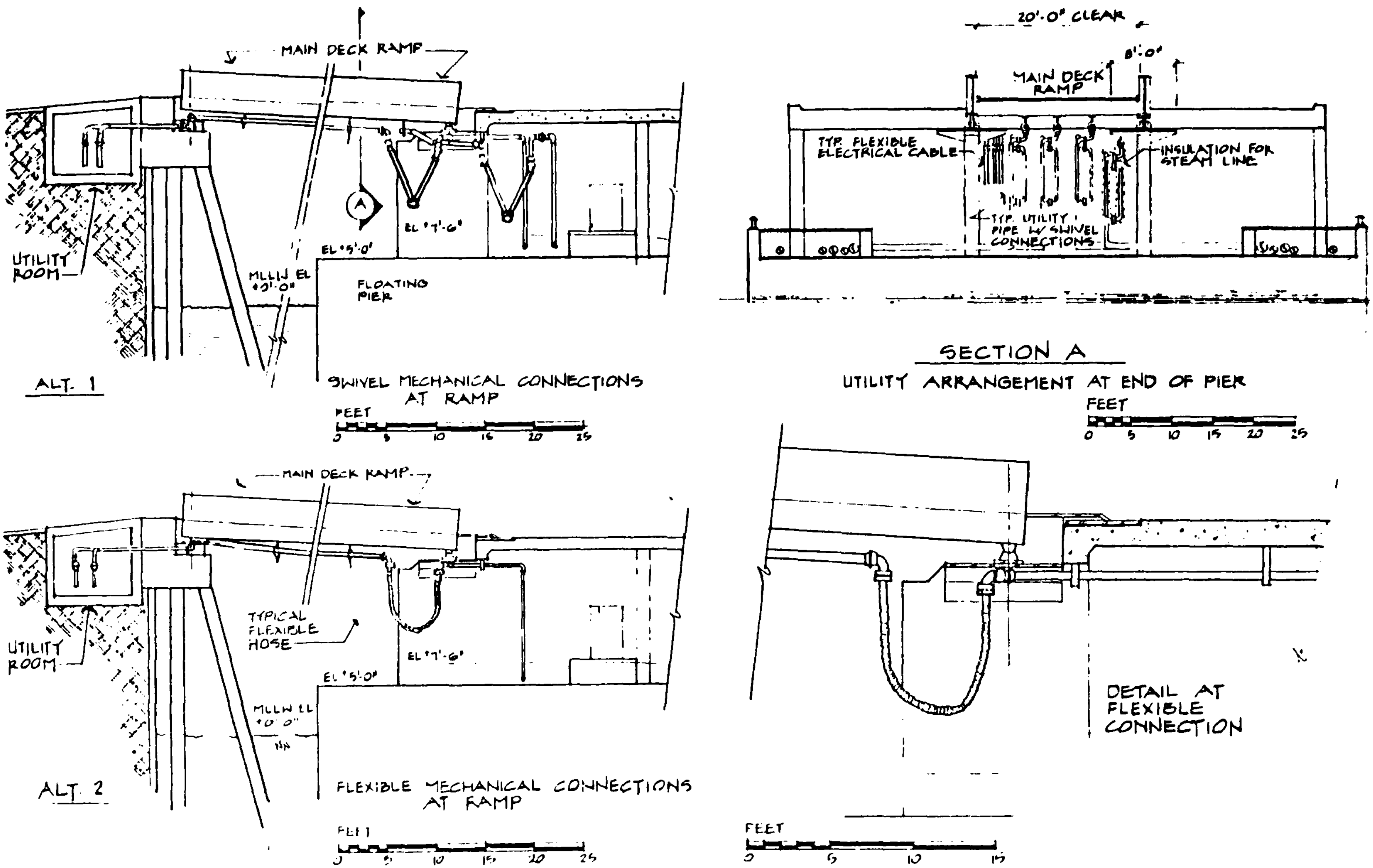


Figure 6-14. Floating Pier Shore-to-Pier Mechanical Connections.

are positioned at each berth. The manifolds have been provided with 2-inch as well as 3/4-inch diameter adapters to match the design of the ship's quick disconnect fittings. It is assumed that the compressed air supply is dry.

c. Steam

One 10-inch steam header pipe is recommended for 150 psi, 365°F service. This line is equipped with in-line metal expansion joints, pipe shoes resting on guide plates, steam condensate liquid traps, 2-inch thick calcium silicate insulation and an overall aluminum sheath.

The use of in-line expansion joints is selected over the use of expansion loops due to the possible limited available space in the pipeway. Pipe shoes and guides are required to permit the pipe to move under controlled conditions as a result of temperature variations. Automatic operating steam condensate traps are essential to evacuate the line of liquid during periods of low steam usage and/or cold ambient temperatures. Sheath insulation is provided for heat conservation, personnel protection, and mechanical protection of the insulating material.

Steam hose service stations are provided at each berth as shown in figure 6-15 with 2-inch outlets.

d. Potable Water

An 8-inch header is provided to operate at a nominal 60 psig pressure. Hose stations fed from this header are selectively located at each berth. Hose station manifolds shown in figure 6-15 are equipped with 2-1/2 inch fittings.

e. Sewage

An 8-inch header is provided, as shown in figure 6-15, to receive effluent from ship sewage lift pumps. Hose stations, equipped with check

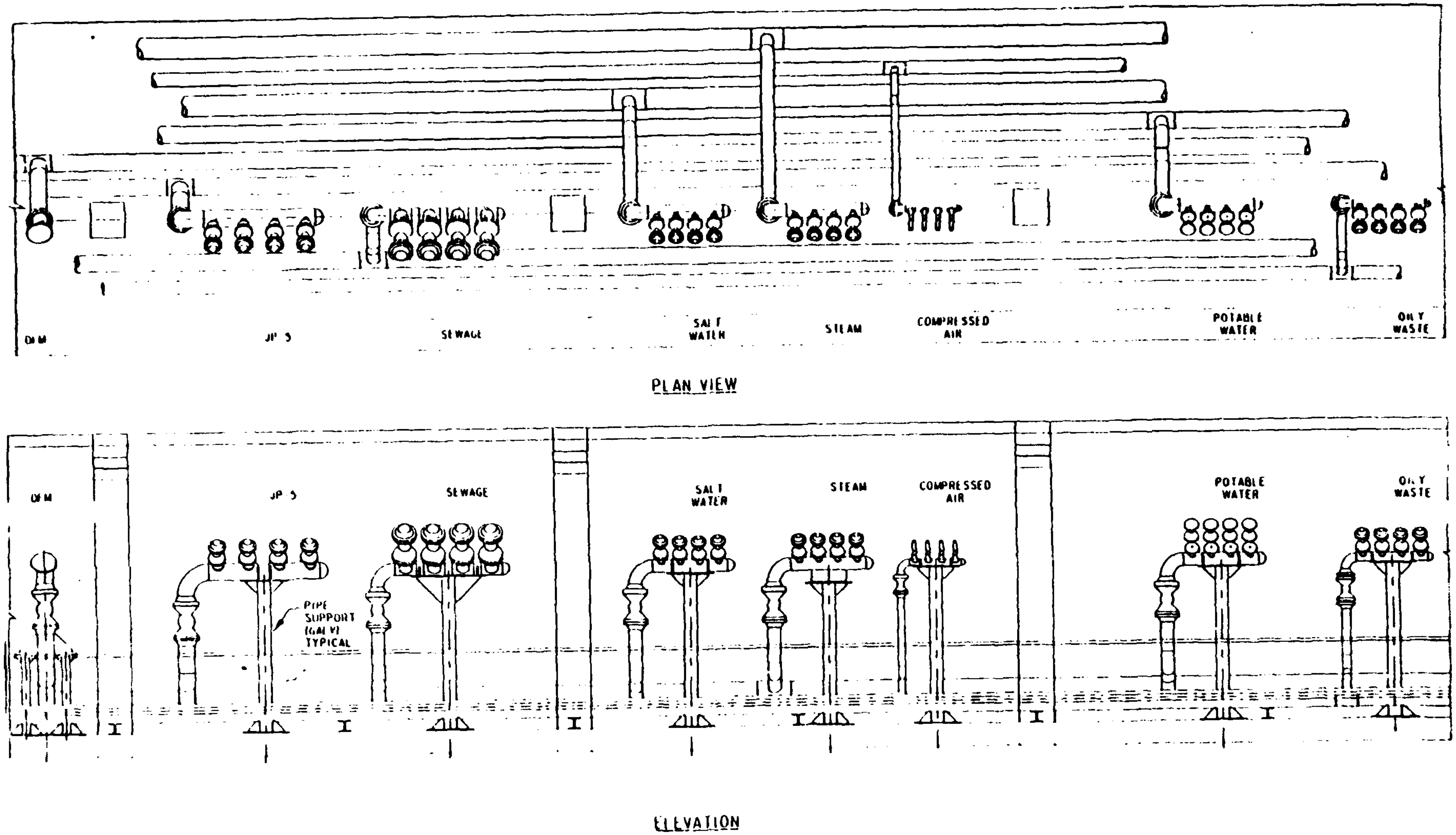


Figure 6-15. Mechanical Systems Manifolds, Typical of Pile-Supported and Floating Pier Utility Galleries

valves and 4-inch fittings, are located at each berth. This design eliminates the need for multiple lift stations.

f. Saltwater

Saltwater hose stations are provided at each berth. Stations as shown in figure 6-15, are equipped with 4-inch and 2-1/2 inch couplings above the gallery pipe chase grating.

g. Firefighting

The proposed firefighting system is self-contained on the pier and is isolated from any onshore firefighting facility. It is a saltwater-flooded system under pressure at a nominal 150 pounds. The system conforms to NAVFAC DM guidance for small and medium surface combatants, and provides a service range of 2,000 to 4,000 gpm at 150 psi for 120 to 180 minutes duration.

The 10-inch diameter looped header is segmented with in-line block valves for improved service continuity and ease of maintenance. Line pressure is automatically maintained under static conditions with an auxiliary electric motor-driven pump of 20 gpm rated capacity. At any time this auxiliary pump fails to maintain system water pressure, one main fire pump automatically starts and continues to operate until manually stopped.

Each main fire water pump has a rated capacity of 2,000 gpm at 150 psi. One main pump is electric motor driven and one main pump is diesel engine driven. Each pump and driver will be designed, built and tested as a unit. All pumps, prime movers and all other equipment, including automatic accessories, shall be listed by Underwriters Laboratories (UL) or Factory Mutual Laboratories (FML).

Each unit is controlled through an approved control panel. The diesel engine-driven unit is equipped with an air-driven starter and a 275-

gallon fuel tank sized in accordance with National Fire Protection Association (NFPA) Section 20. A compressed nitrogen backup supply to the pier air supply is provided. The electric motor-driven pump is served from a dedicated 460 volt, 3-phase power feeder via a 1,000 KVA transformer provided for pier electric power and lighting service. The pumps, drivers, and control panel are located on the lower deck.

Four fire water hydrants will be located on the sides of the upper deck, two on each side, staggered on 300-foot centers which provides a hydrant every 150 feet along the pier. The hydrants will be fabricated from 6-inch pipe with two 2-1/2-inch outlets and a 4-1/2-inch nozzle. A 2-1/2-inch valve will be connected to the 2-1/2-inch outlets and a 4-1/2 inch valve will be connected to the 4-1/2-inch nozzle and will control seawater flow to the threaded hose connector.

h. Above the laterals, a structurally self-supported, industrial-type grating would provide for both access to the hose stations and storage of hoses and cables. This grating would be removable in sections for access to the utility mains and laterals for maintenance and expansion. The stems of the sectionalizing valves should project upward through the grating or extension handles should be provided so they may be operated without removing grating sections. After removal of the grating from above the pipe mains, there is a minimum clearance of 4 to 6 inches around each pipe giving access for maintenance and repair, painting, and housekeeping activities.

6.5.2 Stations. The utility services are provided to the ships from stations located within the gallery on the lower deck. The station concept minimizes the number of stations needed while maximizing their location convenience for the ships. Manifolds are positioned for convenience and safety of operation, and use modern methods for their fabrication. The proposed locations of

the stations are shown in table 6-5 and figure 6-5. The location of the service stations on the lower deck isolates personnel operating them from the upper deck activities, thereby eliminating exposure to hazards associated with upper deck activities. Also, the separation of electrical and mechanical services along the lower deck of the pier allows several operators to concurrently make up or disconnect the various services with minimal interference.

6.5.2.1 Flow Requirements. The utility requirements listed in table 6-1 are based upon daily or hourly average rates. It was assumed that the peak flow condition would be three times the average rate and the design of the laterals took this into account. Where flow quantities were unavailable, the laterals were sized on an "equal area" basis, providing a lateral cross-sectional area based upon four times the maximum hose cross-sectional area. The fuel services have different requirements in that the fuel is taken on board at a specific design rate for a fairly short period of time. Quantity requirements for the fluid flows were checked, where possible, against hose connector sizes. Since F-76 requires a connecting hose of approximately the same size as the main, the laterial is given the same size as the main. Similarly, four JP-5 hose nozzles represent approximately the same size as the main. The lateral is given the same size as the main. The hotel quantity requirement was used for saltwater. When required low quantities were used as a basis of design, general industrial and process plant sizing criteria were utilized.

For any given service, table 6-1 indicates considerable variation in flow requirements and in hose connection types and sizes. Therefore, the manifold connection sizes provided in the design of the hose stations are the largest required for any design ship considered. When necessary, adapters may be used for the shipboard connections. To standardize hose sizes, these adapters

should be used at the shipboard terminus of the hose. An exception to this is compressed air, for which manifolds have been provided with several 3/4-inch-diameter adapters to match design of the ships' quick-disconnect fittings. The manifold inlets are sized as an extension of their incoming laterals.

Service for one berthed ship and one nested ship at each berth is provided plus spare connections. Since several of the design ships have duplicate connections at the same location, and data was not available for all ships, four hose connections were provided at most manifolds. The F-76 manifold is the exception where only one connection is provided because of the limiting main size.

6.5.2.2 Station Descriptions. In general, for the materials of construction, no significant changes from present industry standards are anticipated or recommended for the near future. However, the use of welded-steel manifolds is recommended for hose stations, but does represent a deviation from current practice for some services. Welded-steel construction is commonly used for F-76, JP-5, steam, and sometimes compressed air services. However, the use of flanged, cast-iron fittings for water-related services such as saltwater, sanitary sewage, oily waste, fire water, and potable water is almost universal due to their inherent long life, municipal codes, American Water Works Association (AWWA) guidelines, and other regulations for water supply services. The use of welded-steel manifolds is recommended for these services based upon the excellent record from the petroleum industry. When the manifolds are hot-dip galvanized both inside and outside after fabrication, no problems should arise if adequate and strategically located small couplings are added to the manifolds to prevent air pocketing during the dipping process.

The concepts locate the mechanical stations relatively close together as shown in figure 6-5. They are designed, therefore, as compactly as possible

without sacrificing operability. The length of the stations is reduced by the use of flanged manifolds of welded fabrication using lateral-sized pipe and fittings. Hose connection nozzles are spaced as close together on the manifolds (considering the sizes and types of couplers involved) as is consistent with adequate clearance for make up of the hoses at the connection. In most cases, the use of weld-o-lets, or other commercial, welded-type nozzle outlet reinforcing pads (instead of welded tees) is recommended to save space. The sanitary sewage station is an exception to this because 6-inch-diameter hose nozzles could not be placed much closer together than the 14-inch dimension of a standard 8-inch-diameter welded tee fitting. A substantial savings in space is derived by the use of welded manifolds instead of conventional cast-iron, flanged fittings. The elbow entry to the manifold also saves space over a welded tee and two weld caps and represents a hydraulic advantage over a tee entry, since approximately four to five times more line friction loss is encountered through a tee as through a long radius welded elbow.

Potable water stations are recommended which incorporate reduced pressure principle backflow preventers, with spring-loaded swing check and bleed mechanisms, which do not require horizontal installation. The bleeds should be left open for observation.

All clean services, such as compressed air, saltwater, potable water, and especially steam, incorporate the use of depressurizing bleed connections at each hose nozzle outside of the valve to prevent accidental uncoupling of a pressurizied hose that is still connected at the shipboard end. Compressed air stations include several reducing adapters with 3/4-inch-diameter quick disconnect couplers attached with chains to prevent loss. Saltwater connections for both fire water and shipboard usage are on the lower deck. The connection of a fire hose to combat a nearby fire is probably more safely made below deck

than above, however, a parallel set of fire hose stations located on the upper deck level could also be provided if desired. Sewage stations are equipped with a 2-1/2 inch-diameter nozzle, to which a saltwater hose could be attached for the application of saltwater main pressure, should this become necessary. All stations are provided with coupling caps or flanges for manifold nozzle closures, and are attached to the manifolds by chains.

The hose connection nozzles are "trained" or pointed in the general direction of the "on board" connection based upon the locations and differences in elevation connections. The manifolds will be supported by tee or L stanchions anchored to the lower deck.

The self-draining aspect of the manifolds, provided by the location of the manifolds above the mains, precludes the need for traps at the steam or compressed air stations. This results in a space saving since "boots" or drip legs are not required. Trapping for these services is, therefore, required only at the main. Although present operations usually allow steam condensate to be dumped, a condensate return main my be required in the future. Compressed air traps may be discharged into the oily waste main. Provision for thermal expansion and contraction of the mains is anticipated to be made within the space provided for each main within the pipeway by expansion joints, a practice currently in widespread usage. However, the location of the steam line in the pipeway will allow the use of shallow loops, if so desired. Trapping would then be required on either side of the vapor pocket formed by the loop.

6.5.2.3 Station Operation. A wide range of hose weights is encountered for the various services. These range from approximately 25 pounds for a 50-foot length of 3/4-inch-diameter compressed air hose, to approximately 1,150 pounds

for a 50-foot length of 8-inch F-76 hose with flanged ends. Heavy-duty steam hose weighs approximately 250 pounds per 50-foot length when fitted with the threaded brass drive couplers.

While potable water, saltwater, fire, oily waste, and compressed air hoses are within the lifting capacity of one man, steam, sewage, JP-5, and F-76 will require two or more men for handling. Consequently, the use of external lifting devices, either on the pier or onboard the ship being serviced, is advisable for the heavier lines. The station design, therefore, is based upon the concept that only one man would be needed on the lower deck to make up or break the hose-to-manifold connection and to operate the valve.

The station manifolds are located along the outer edge of the lower deck. Since the upper deck is set back from the lower deck, the hose lengths may be lowered to or raised from the station while vertically supported either from an external device or by seamen aboard the ship to be serviced. The manifolds are located above the gallery grating at a height of approximately 3-1/2 or 4 feet which is convenient for making the connection. The hose connection can, therefore, be made by one person standing erect within the gallery and facing the ship. Eye contact can be maintained by the man on the pier's lower deck with the crewman on the ship's deck, or with the equipment operator or the man directing the lifting of the hose. The hose connection may then be made without the need for the person who is making the connection to simultaneously support a portion of a heavy hose.

Access to utility stations is provided by ladders from the upper deck at each station location and by vehicular access from the shoreward end of the pier. Vehicular crossover can be provided at the seaward end of the pier and at other areas as required. Access to the lower deck should probably be

restricted to Public Works Department personnel and others having a need for such access.

6.5.3 Storage. Small hoses used in services which do not require cleaning after each usage may be stored on the lower deck gallery grating either flaked, in coils, or on reels. They may alternately be strung out lengthwise atop the grating to facilitate drying when necessary. This arrangement could be adopted for compressed air, steam, saltwater, and fire water hoses. Potable water, F-76, JP-5, oily waste, and sanitary sewage require some sort of decontamination or cleaning procedure after each usage. It is envisioned that the storing of hoses on the deck gallery grating would be done selectively such that the areas adjacent to the hose stations would remain clear at all times so as not to impede personnel access.

Compressed air hose, in sizes ranging from 3/4 inch to 1-1/2 inches, may be readily stored on manually-powered reels or simply coiled and left on the grating near the hose area. Depending on the size of any such reels, they could be mounted overhead at the station, attached to the underside of the upper deck, or placed beneath the manifold. The stiffer steam hose would require a larger reel diameter and probably would be more easily left in coils on top of the grating. A 50-foot length of steam hose with connectors weighs 200 to 250 pounds and requires supplemental lifting for easy coiling.

Hoses requiring sanitization after each usage are usually transported to an off-pier site for treatment. They are not returned until shortly before reusage. Regardless of the configuration in which they may be returned (coiled, flaked, loose or on pallets), adequate space is available on the grated area above the wide pipeway serving the stations for their storage. Due to the weight involved, 50-foot lengths of F-76, JP-5, and sewage hose will require

lifting equipment on, or available to, the hose return vehicle, or extra manpower must be available for their unloading. The development of portable units for in-place cleaning of these hoses below deck could warrant consideration.

6.5.4 Steam Purity. Current Navy Ship Technical Manual (NSTM) NAVSEA criteria for steam purity places many demands upon the shore station to maintain and monitor the quality and purity of steam being delivered to Navy ships. Impure steam can originate from changes in raw water source constituents, incomplete water treatment, boiler carryover, malfunctioning steam traps, and contaminated steam lines.

In order to meet the NSTM requirements for steam purity outlined in table 6-8, the Navy has maintained a technological development and assessment program to evaluate ways of improving steam purity and monitoring four main characteristics of steam indicative of the purity level; i.e., pH, conductivity, silica and hardness levels. The Navy's main technological approach has been directed at:

- Testing and evaluating steam separators as to effectiveness for removing impurities.
- Developing a steam purity measurement system for monitoring steam.

Table 6-8. Physical Property Requirements for Steam Delivered to Navy Ships*.

PHYSICAL PROPERTY	REQUIREMENT
pH	8.0 to 9.5
Conductivity	25 micro mho/cm max
Dissolved Silica	0.2 ppm max
Hardness	0.1 epm max (5.0 ppm as $CaCO_3$)

Note: * Taken from NSTM NAVSEA S9086-6X-STM-020/CH-220 V2 R3, September 1981

6.5.4.1 Steam Separators. Different type separators were tested and assessed for their ability to improve the quality and purity of shore steam conveyed to the berthed ships. They included:

- Cyclone
- Wire mesh
- Vane

The separators were tested for steam flows ranging from 25 to 125% of separator rated velocity and boiler carryover levels from 1 to 65%. Separator performance under steady-state and transient operations was observed and reported in NCEL Technical Note TN No. N-1586. In summary:

- During steady-state boiler operation when steam satisfied the Navy specification except for pH, the separators provided little measurable improvement.
- Under steady-state and transient conditions when simulating boiler carryover (1 to 65%), the separators dramatically reduced the steam impurity levels.
- The separator efficiency was found dependent upon steam flow rate and quality. No single separator performed best for all test conditions, and compromises are required. In general, all the separators assure greater than 90% efficiency.
- For carryover less than 10%, any separator having greater than 90% specific efficiency appears adequate as shown in figure 6-16.
- For carryovers greater than 10%, separators would required near 99% efficiency as shown in figure 6-17.
- In general, the separator efficiency dropped as the steam flow rate increased, as shown in figure 6-17.

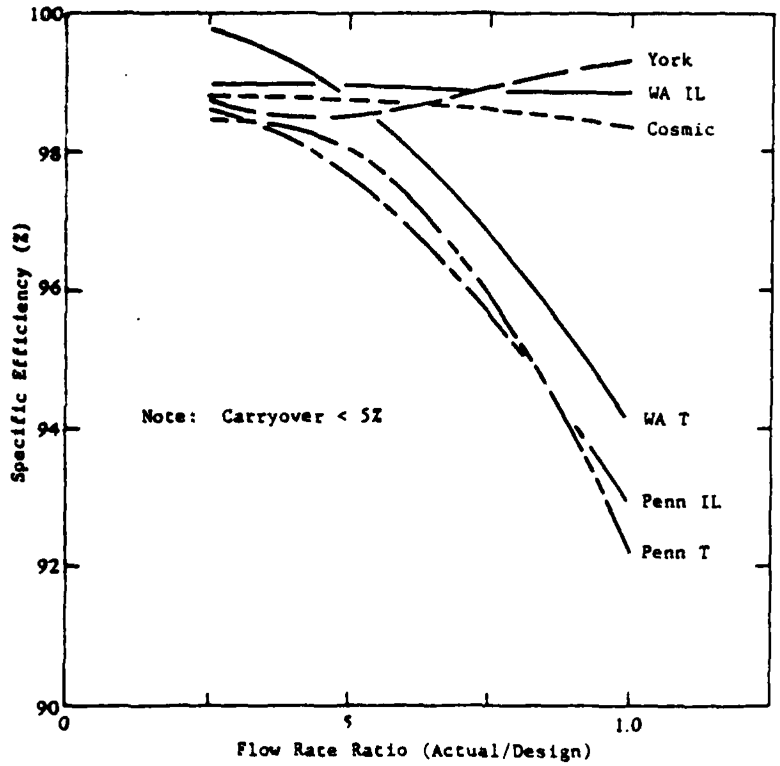


Figure 6-16. Minimum Efficiency Boundary: Low Carryover.

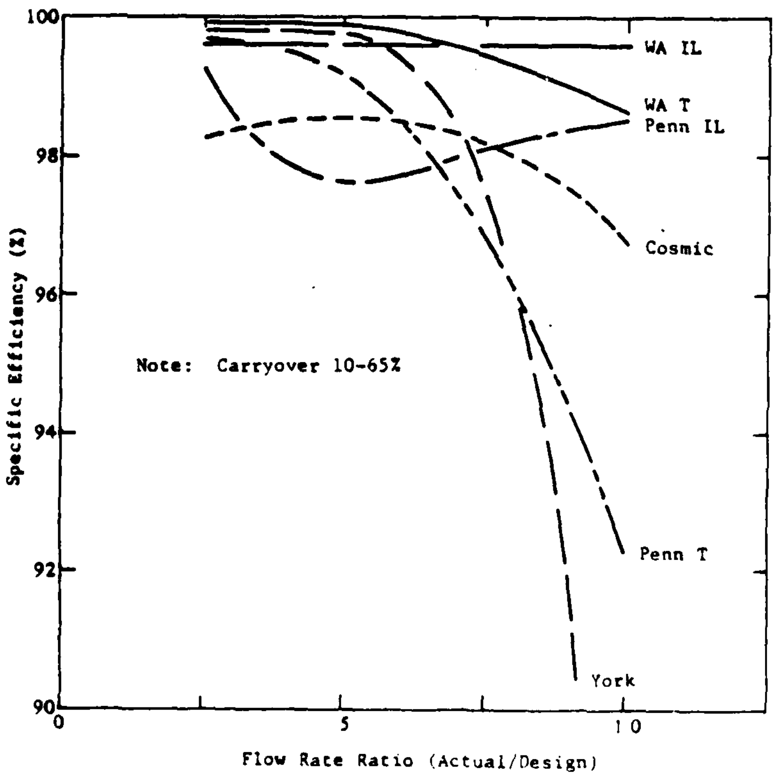


Figure 6-17. Minimum Efficiency Boundary: High Carryover.

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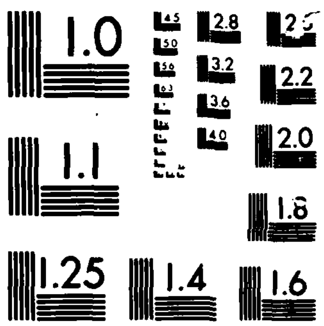


MICROCOP' CHART

- Moderate separator efficiencies (<60%) encountered with already pure steam appear to be due to separator threshold droplet sizes (near 10μm).
- For similar design requirements, separator sizes and weights vary widely and may control final selection.
- Dissipative losses of some units are significantly greater than those of others. Separator losses are generally low.
- One option to achieve the highest overall performance is use of a tandem system. A high carryover-efficient separator followed by a low carryover-efficient one would capitalize on both separator attributes.

Test and evaluation effort on steam separators resulted in the following recommendations:

- Use separators for protection from carryover, especially boiler upset conditions. Separators proved effective in reducing impurity content of steam during carryover.
- Slightly oversize the separator, since the efficiency generally falls as the rated velocity is approached.
- Consider the option of two separators in tandem for extreme carryover levels.
- Selection of one separator over another depends upon separation performance, dissipative loss characteristics, geometric size constraints, and RAM properties.
- Select traps based on anticipated massive carryover levels. Since trap selection can control separator performance, dual traps and sump should be considered for abnormally high carryover conditions or temporal slug flow.

6.5.4.2 Steam Purity Measurement System. NCEL has developed a steam purity measurement system (SPMS) capable of measuring and recording the pH, conductivity, silica, and hardness levels of steam on a continuous basis, as well as sounding an alarm when any of the levels are exceeded.

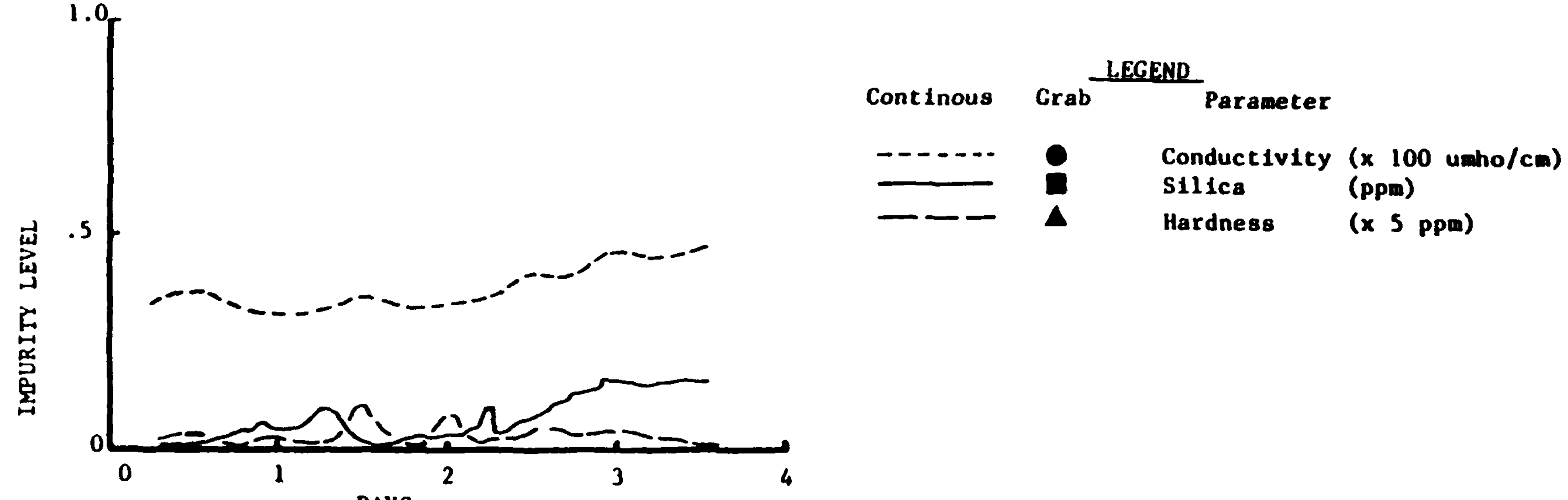
As a result of an 8-month technical evaluation, the SPMS met all the basic design requirements, demonstrating a reliability of 0.956 with 0.02 maintenance manhours per operating hour. Accuracy of the analysis results was shown to be within equipment manufacturer's specifications; i.e., ±2% to ±5% dependent upon the instrument.

Figure 6-18 shows typical steam purity excursions using both continuous monitoring and grab sampling measurement techniques. With the use of continuous or real time impurity analysis, the problem may be immediately circumvented; whereas, grab sampling techniques may allow the problem to go undetected.

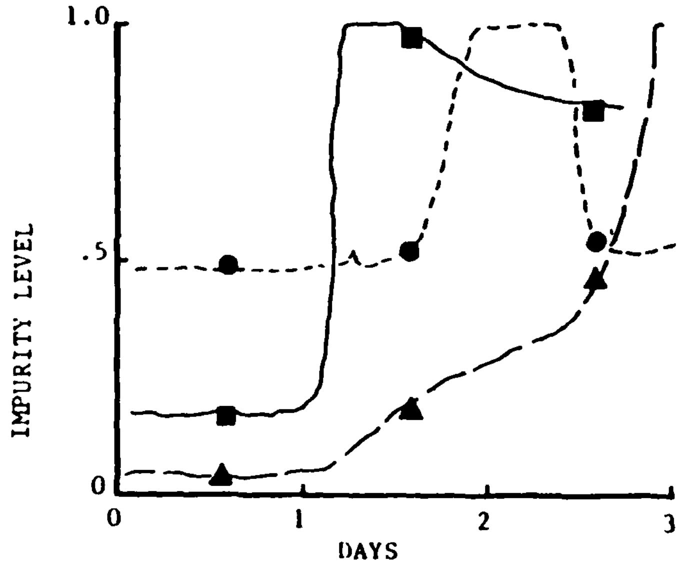
The steam purity monitor field system is designed as a complete packaged unit, housing the pH and conductivity monitors, silica and hardness aqualyzers, recorders, sample coolers, gauges, valves, and supporting electrical and mechanical systems.

The field system is divided into two sections: the sample input section, and the analysis section as shown in figure 6-19. The sample input section contains all the support equipment necessary to provide the analyzers with a properly cooled and pressurize regulated sample, and is designed to protect the system against two critical variables of the sample stream; pressure and temperature.

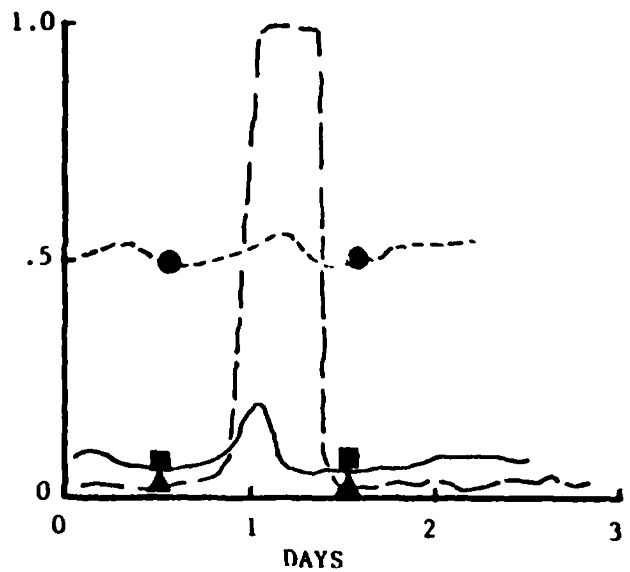
The sample input section is designed so that it can isolate the sample (1), and blowdown the incoming steam sample (2). The sample is then cooled (3),



6-18a. TYPICAL PROFILES

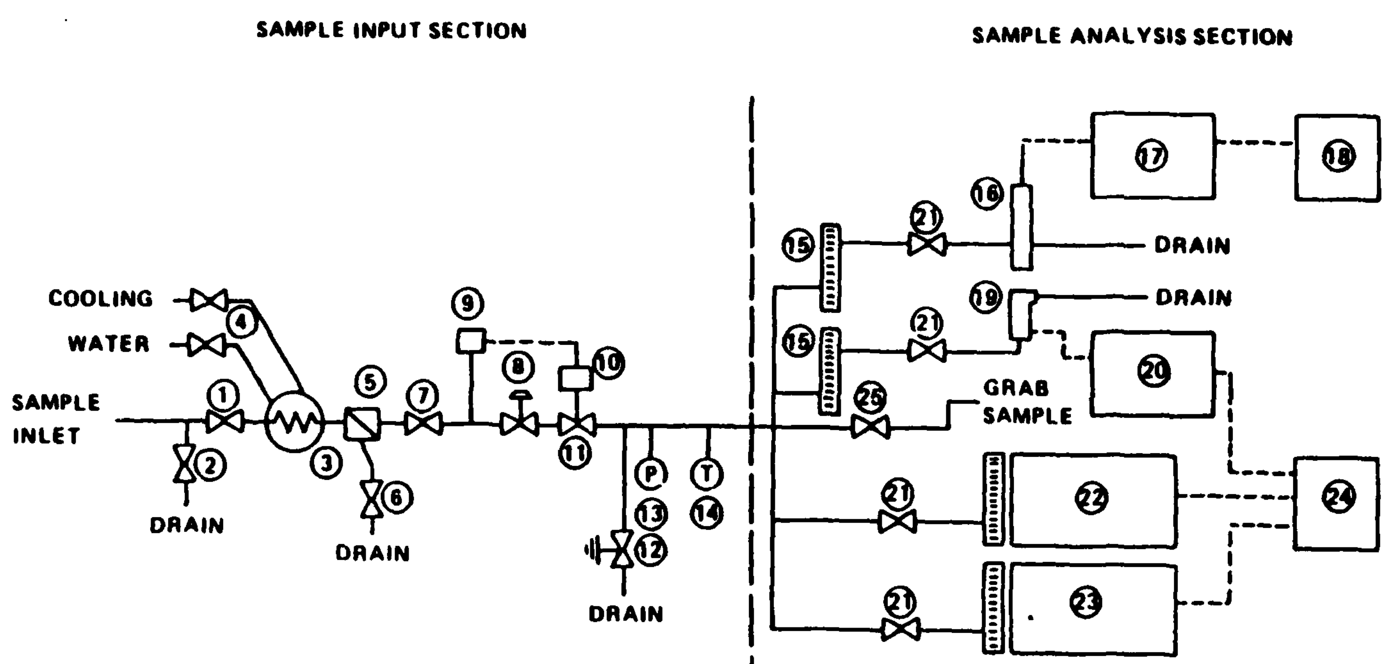


6-18b. MAJOR BOILER UPSET



6-18c. INTERMITTENT UPSET

Figure 6-18. Typical Normal and Upset Conditions Measured (Continuous and Grab Sampling).



1. SAMPLE LINE ISOLATION VALVE
2. BLOWDOWN VALVE
3. SAMPLE COOLER
4. COOLING WATER ISOLATION VALVES
5. STRAINER
6 BLOWDOWN VALVE
7 SAMPLE ISOLATION VALVE
8 PRESSURE REGULATOR
9 TEMPERATURE SWITCH
10 RELAY
11 SOLENOID VALVE
12 PRESSURE RELIEF VALVE
13 PRESSURE GAUGE WITH ISOLATION VALVE
14. TEMPERATURE INDICATOR
15. FLOW CONTROLLER
16. pH ELECTRODE
17. pH MONITOR
18. RECORDER
19. CONDUCTIVITY CELL
20. CONDUCTIVITY MONITOR
21. INSTRUMENT ISOLATION VALVES
22. SILICA MONITOR
23. HARDNESS MONITOR
24. RECORDER
25. GRAB SAMPLE VALVE

Note: The final design may be altered to place the pH and conductivity meters in series with bypass lines.

Figure 6-19. Steam Purity Measurement System Diagram.

strained (5), and reduced in pressure (8) to 10-60 psig. High sample temperature protection is provided with a temperature switch (9), relay circuit (10), and solenoid valve (11). Pressure protection is provided by a pressure relief valve (12).

The cabinet housing the system, consists of a 42 inch high x 72 inch wide x 24 inch deep, 14 gauge NEMA 12, double door, freestanding enclosure, with dual access, front and back. A drip shield is provided over the doors, front and rear. An I-beam, 6-inch high base with slots for forklifting is provided on the bottom of the enclosure. The front and rear of the enclosure have two single doors with a removable center post between them. Each door has a three point latch and padlocking handle. Ten 8-inch louvers are provided, at the top and bottom of each side of the enclosure and at the top and bottom of each rear door. A 12-gauge steel barrier is provided inside the enclosure located 4 inches from the font with holes, cutouts, and a 15 inch high x 12 inch wide x 6 inch deep enclosure, for mounting the instruments and readout meters. The base coat is ZRC in and out with the inside finish being white enamel and the outside finish being gray enamel. The weight of the enclosure empty is 579 lbs.

The electrical system is designed to provide 60 amp, 220 volt power to the cabinet. Additional circuit breaker capacity is provided for a space heater and fan, and an alarm.

6.6 Other Utilities

6.6.1 Telephone System. Telephone service for the docked ships is provided by weathertight telephone cabinets included as part of the electrical mounds, located on the lower deck near the center of each berth on both sides and at the sea end of the pier. These weatherproof compartments contain terminals

identified by standard numeric code for connection by portable cable to the docked vessels' ship-to-shore telephone system. An empty conduit system is provided consisting of PVC coated, galvanized steel conduit (or equal) with pull wires supported from the underside of the upper deck. All conduit systems connect the nine telephone cabinets to the shore end of the pier's upper deck ramp. A conduit for public telephones is located at the shore end of the pier and is also connected

into the telephone conduit system.

6.6.2 Fire Protection and Alarm Systems. There are two systems proposed on a double-deck pier: a manually initiated, audible fire alarm system for both upper and lower decks, and a manual and smoke-activated Halon flooding system for the vaults and pump room on the lower deck.

a. Alarm System. A fire alarm system is provided for the pier and consists of manual pull stations, alarm bells, a central control cabinet, and a connecting conduit system. All conduit is routed to the shore side of the pier's ramp for connection to a shorebased fire alarm system.

Pull stations are located on the upper deck at the base of the six floodlight stanchions and on the lower deck at approximately 200-foot intervals along the length of the pier. The central control panel is located in an electrical equipment vault closest to the pier entrance.

The system is a fail-safe, hardwired, manually actuated, audible alarm system intended for the pier only.

b. Halon System. The electrical equipment vaults are protected from fire damage by a Halon system designed as a total flooding system for inert concentrations of Halon 1301. The system is complete for each of the three vaults and the first pump room. The system is equipped with a fixed supply of Halon 1301 in cylinders attached to a system of fixed piping with nozzles arranged to discharge simultaneously into the vault.

Actuation of the Halon system is by smoke-detector sensors located near the ceiling of the vault and by a pneumatically-operated switch located outside the vault. Operation of the system will initiate de-energization of the switchgear, activate the audible fire alarm and shutdown the fault ventilation blowers.

6.6.3 Catholdic Protection System. An improved current system is provided for cathodic protection of the steel pilings securing the floating pier.

Three rectifier-type power supply units are located in the electrical equipment vaults on the lower deck. These units are liquid-filled with a galvanized sheet steel tank-type enclosure and include metering equipment. Primary voltage is 480 volts ac and output voltage is 20 volt dc. These units provide protection for the 56 pier pilings, 12 abutment bearing piles and 210 lineal feet of sheet steel piling at the abutment. This improved current system requires six anodes.

The two Med-mooring pilings are protected with sacrificial anodes.

6.7 References.

The materials contained in this section have been extracted from the following documents:

- NCEL CR 83.032, Conceptual Designs for Berthing Pier Galleries and Deck Lighting, Brown & Root Development, Inc., June 1983
- NCEL Technical Note, TN no. N-1586, Steam Separator T&E, August 1980
- NCEL Technical Memorandum no. M-62-82-03, The Suitability of an Automatic Voltage Regulator to Solve Shore-to-Ship Power Regulations Problems, May 1982

- NCEL Technical Note TN no. 1689, Port Systems Project: Shore-to-Ship Electrical Power Cable Handling Equipment, April 1984
- User Data Package, Shore-to-Ship Electrical Power Cable Handling Equipment, March 1984
- VSE Report, Ship Data and Berthing Requirements for Small and Medium Surface Combatants, March 1983
- VSE Report, Pier Utilization Study for Small and Medium Surface Combatants, September 1983
- Brown & Root Development, Inc. Report, Floating Pier Concept, Preliminary Engineering Studies and Preliminary Construction and Life-Cycle Cost Estimate at Pier 92, Port of Seattle, Washington, December 1983
- VSE Report, Steam Purity Measurement System Feasibility Report, April 1984

SECTION 7

PIER LIGHTING

Pier lighting is generally considered to be substandard on most Navy piers. The most common types of lighting now in use are curb lighting, centerline lighting, shed mounted lighting, portable ship mounted lights, portable pier mounted lights, and light trailers.

This section provides a design concept for both main deck lighting and lower deck lighting, when a double deck pier is involved. The section includes:

- Recommendations for illuminance levels.
- Lighting alternatives.
- Recommended design concepts for main deck pier lighting.
- Recommendations for lower deck lighting.

7.1 Lighting Requirements

The primary criteria source for lighting is NAVFAC Design Manual DM-4.4, "Electrical Engineering - Electrical Utilization Systems," December 1979, Sections 7 and 37. The manual addresses area lighting and recognizes the "Illuminating Engineering Society of North America" (IES) as the reference authority when no specific criteria is otherwise provided. The IES Lighting Handbook classifies numerous pier tasks and assigns recommended light criteria conditions for each task, fully recognizing that the implementation of that criteria may not be met on as large an area as a pier. The IES Publication ANSI/IES RP-7 1983 provides further American national standard practices for industrial lighting, including port area operations.

Pier lighting is needed for security, safety, and specialized high-tempo tasks which may be grouped into three categories:

- Main deck activity involving:

-- Moving vehicles such as automobiles arriving, parking, and departing.

-- Driving, maneuvering, and positioning vehicles that handle cargo.

-- Operating boomed vehicles that hoist and lower cargo.

- Transferring cargo plus transport and security of rigging for cranes; i.e. shackles, hooks, bridles and slings.
- Ship berthing support, hotel/housekeeping services, intermediate-level maintenance and refit, and the ever increasing operational training.

The first two categories, which are generally manual tasks involving medium to large physical components, have low lighting level requirements. The third category (particularly operational training) often deals with smaller physical components which require color matching and the reading of written material, and as a result, requires a significantly higher lighting level.

Based on an evaluation of 18 naval activities, 13 commercial ports, and information obtained from special lighting consultants, it is concluded that lighting levels on a Navy pier should provide for 2 to 5 footcandles in work areas and a minimum of 1 footcandle in nonwork areas. Lighting levels as low as 0.5 footcandles would provide adequate lighting for foot traffic, entrances to piers, corners of piers, and isolated perimeter spots between berths. Tables 7-1 and 7-2 provide revised American national standard practices for industrial lighting as published in the IES Publication ANSI/IES RP-7 1983.

Table 7-1. Illuminance Levels for Safety.

Hazards Requiring Visual Detection	Slight		High	
Normal Activity Level[†]	Low	High	Low	High
Illuminance Levels				
Lux	5.4	11	22	54
Footcandles	0.5	1	2	5

* Minimum illuminance for safety of people, absolute minimum at any time and at any location on any plane where safety is related to seeing conditions.

† Special conditions may require different illuminance levels. In some cases higher levels may be required as for example where security is a factor, or where certain colors must be identified. In some other cases greatly reduced levels, including total darkness, may be necessary, specifically in situations involving manufacturing, handling, use, or processing of light-sensitive materials (notably in connection with photographic products). In these situations alternate methods of insuring safe operations must be relied upon.

Table 7-2. Categorization of Port Cargo Handling and Shipping Facilities with Recommended Illuminance for Safety.

Area	Activity	IES Class	Illuminance Lux	Illuminance Foot-candles
General Cargo				
Employee Parking	Pedestrian traffic, security	Slight Hazard/Low Activity	5	0.5
Facility Entrance	Pedestrians access, traffic control, security	Slight Hazard/Low Activity	5	0.5
Open Dock Area	Equipment operator moving cargo with machine. Dockman piling cargo, setting blocks, etc.	Slight Hazard/Low Activity	5	0 5
Transit Shed	Placing cargo, piling cargo, building loads, hand handling	Slight Hazard/High Activity	10	1 0
Front	Landing/hoisting loads, equipment operators, frontman	Slight Hazard/High Activity	10	1 0
Transit Shed	Inactive, security only	Slight Hazard/Low Activity	5	0 5
Low Line	Receiving/delivering of cargo from trucks, rail cars	Slight Hazard/Low Activity	5	0 5
Container/Automobile				
Employee Parking	Pedestrian access, security	Slight Hazard/Low Activity	5	0 5
Facility Entrance	Truck traffic, pedestrian walkways, weighing scales, security	Slight Hazard/High Activity	10	1 0
Storage Yard, Open Dock	Equipment operator moving cargo	Slight Hazard/Low Activity	5	0 5
Transit Shed/Stuffing Station	Loading/discharging containers, piling cargo, equipment operations	Slight Hazard/High Activity	10	1 0
Front/Container—Wharf	Landing/hoisting cargo, securing/releasing chassis devices, pedestrian vehicle traffic	High Hazard/High Activity	50	5.0
Front/Automobile	(Same as Front/Container)	High Hazard/Low Activity	20	2.0
Walkways Through Traffic Lanes	Pedestrian traffic, vehicle operations	Slight Hazard/Low Activity	5	0 5
Perimeter Walkways	Pedestrian foot traffic, security	Slight Hazard/Low Activity	5	0 5
Transit Shed/Stuffing Station	Inactive, security only	Slight Hazard/Low Activity	5	0 5
Bulk Cargo				
Employee Parking	Pedestrian traffic, security	Slight Hazard/Low Activity	5	0 5
Facility Entrance	Pedestrian access, traffic control security	Slight Hazard/Low Activity	5	0 5
Open Dock Area	Moving rail cars, truck dump traffic	Slight Hazard/Low Activity	5	0 5
Dumping Pit	Opening hoppers, rotary and shaking operations	Slight Hazard/High Activity	10	1 0
Conveyor System Point of Operation/Transfer	Observing flow of cargo, control belt system	Slight Hazard/Low Activity	5	0 5

7.2 Main Deck Lighting Alternatives

The use of portable "plug-in" type lights mounted aboard ship, but pier fed, is a hybrid arrangement with multiple disadvantages. This type of lighting system satisfies the "clear deck" restraint by passing the problem to the ship deck and fails to eliminate associated high maintenance, high breakage and high labor costs. Mobile cranes are required to mount and secure large wattage, plug-in luminaires. This task can only be completed after the ship is berthed rather than before berthing, which impacts the scheduling of station personnel.

The use of portable "plug-in" type lights on the upper pier deck also has several disadvantages. The application of any supplemental lighting technique incorporates all the economic disadvantages experienced using the shipboard-mounting scheme. Other negative aspects are that the "clear deck" objective is violated thus causing clutter and safety hazards. The quality of the light obtained will be poor and will produce glare problems.

The use of stanchion-mounted fixtures, with the stanchions being removable from the main deck when not in use, results in a paradox. Permanently mounted stanchions on the main deck offer no interference to main deck usage when there is no activity. When there is no main deck activity, the removable stanchions are secured. When there is main deck activity, the removable stanchions are in use part time. There are no advantages for such an arrangement. The disadvantages include high cost, high maintenance, and high breakage.

The use of recessed curb lighting makes no light contribution to a well-designed berthing pier lighting system. The pier deck is clear but the illumination is inadequate and light patterns are unacceptable.

The use of permanent pole-mounted fixtures provides noticeable advantages in power efficiencies, economics, safety, flexibility, versatility,

and light control. A properly designed system using long-life lamps and high-quality fixtures will be virtually maintenance free, will not require supplemental light, and the areas where work tasks are performed will be uniformly lighted. The disadvantages are that some main deck clutter exists and the lighting system must be designed to match specific pier requirements.

The use of fixtures mounted on a dedicated towable trailer/cart offers some advantages and disadvantages over the previous alternatives. The quality of light over other portable lights does not improve but the time and labor involvement is reduced. There is an overall reduction in deck clutter. First costs are higher.

It should be noted that a permanent deck lighting system should be designed with the idea that no supplemental light will be used, thus avoiding the need even for trailer-mounted portable lights.

7.3 Recommended Main Deck Pier Lighting

7.3.1 Illumination Levels. Lighting levels should be planned for Navy piers to provide 2 to 5 footcandles in work areas and a minimum of 1 footcandle in nonwork areas. Lighting levels as low as 0.5 footcandles provide adequate lighting for foot traffic, entrances to piers, corners of piers and isolated spots between berths.

7.3.2 Lighting Systems Design. Three lighting systems are currently available to satisfy the Navy's illumination requirements for active ship berthing. They are:

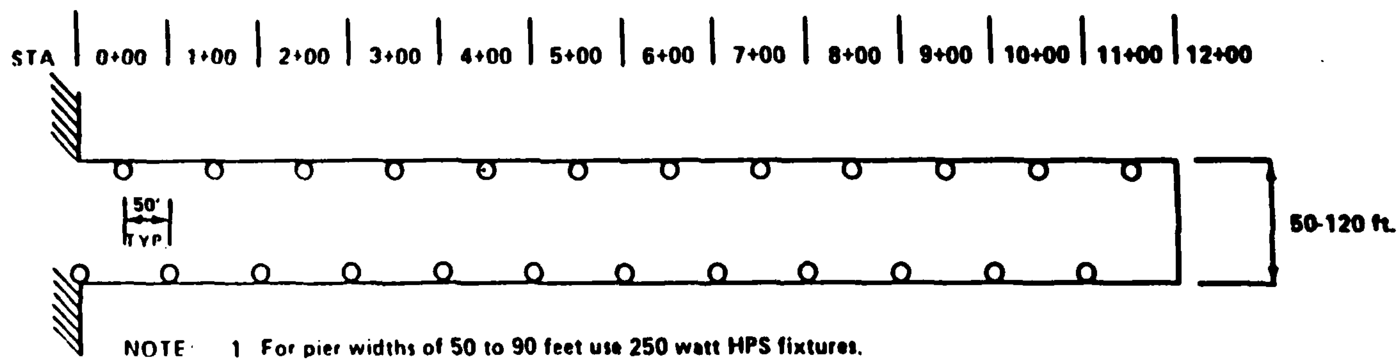
- The use of 250-watt or 400-watt high pressure sodium (HPS) streetlight type fixtures on 30-foot poles, spaced 100 feet on-centers down each side of a pier.

- High mast perimeter lighting using 400-watt HPS power spot floodlights and regular wide beam floodlights, on 100-foot poles positioned at the entrance, midpoint, and outboard end of the pier. Approximate spacing between poles on each side of the pier, dependent upon configuration, would be 600 feet, thereby, leaving the areas in front of the berths clear for pier operations.
- Pier centerline lighting using high mast, 1000-watt HPS downlight fixtures on 80-foot poles, spaced either 200 or 250 feet on-centers.

7.3.2.1 Perimeter Pier Lighting on 30-Foot Poles. For piers with moderate to light activity levels and no major ship overhang problems, the use of 250-watt or 400-watt HPS streetlight fixtures on 30-foot poles, as shown in figure 7-1, may provide the most optimum cost effective lighting approach. The 250-watt fixtures would be used with piers 90 feet wide or narrower; 400-watt fixtures would be used for piers 90 to 120 feet wide. With this type of design, an average lighting level of 3 footcandles can be provided in the working areas, and glare should be nonexistent. If very low activity levels are planned for the working areas, the pole spacing may be increased depending upon the illumination levels required and pier width. In no case should pole spacing exceed 250 feet.

Figure 7-2 shows the typical light standard to be used with the streetlighting arrangement.

Figure 7-3 provides a standard illumination diagram for a 1200-foot long by 80-foot wide pier using 250-watt HPS fixtures on 30-foot poles, spaced 100 feet on-centers, and using a maintenance factor of 0.85 to provide adjustment for luminaire deterioration and dust. Illumination levels vary between



NOTE: 1 For pier widths of 50 to 90 feet use 250 watt HPS fixtures.
2 For pier widths of 90 to 120 feet use 400 watt HPS fixtures.

Figure 7-1. Recommended Perimeter Pier Lighting Using 30-Foot Poles and 250-Watt or 400-Watt HPS Streetlight Fixtures.

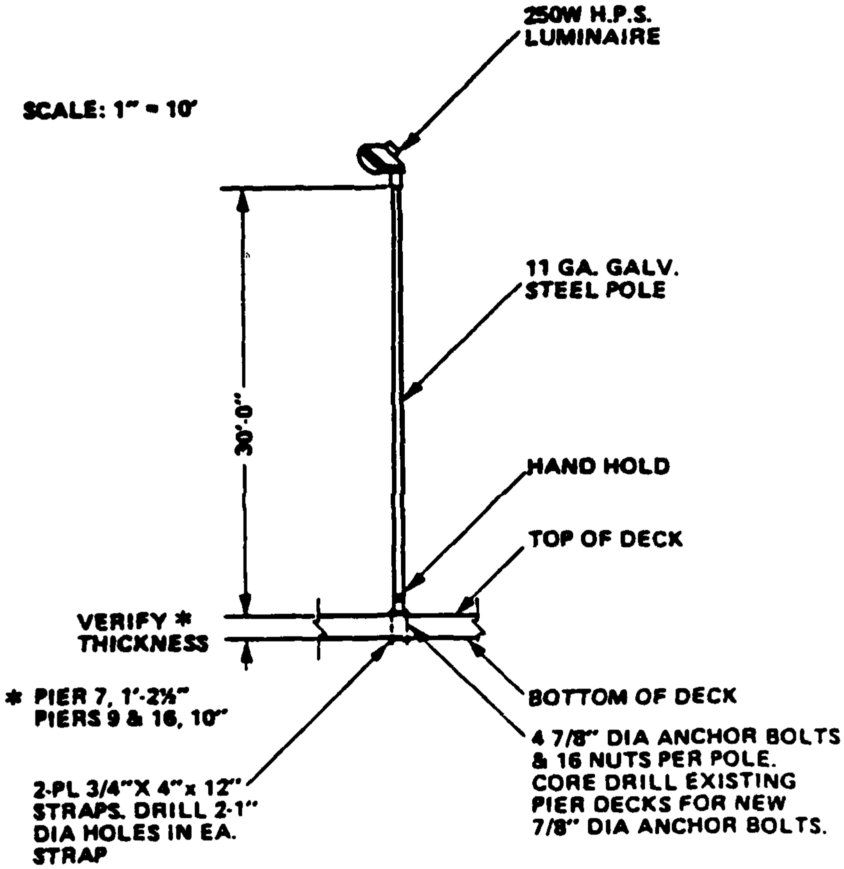


Figure 7-2. Typical 30-Foot Light Standard.

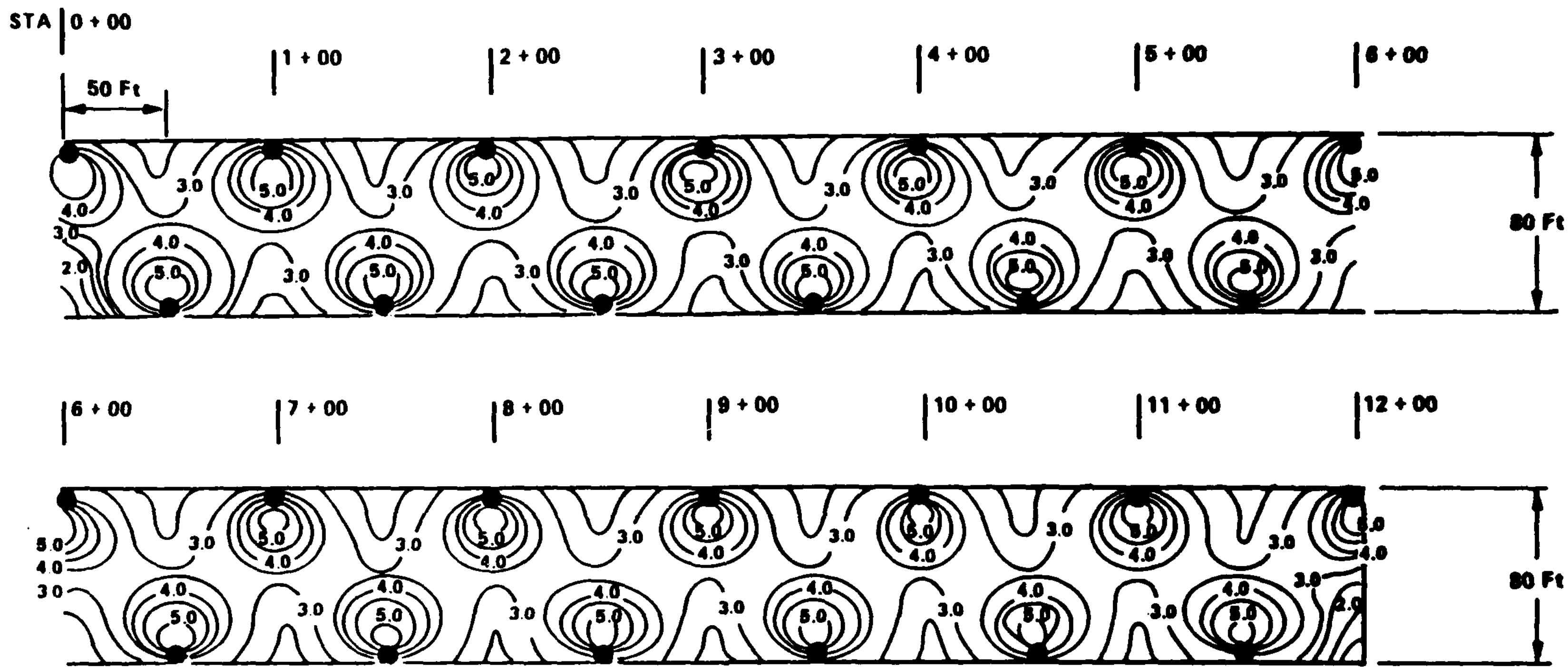


Figure 7-3. Standard Illumination Diagram, in Footcandles, 1200-Foot Long by 80-Foot Wide Pier, Using 30-Foot Poles and 250-Watt Fixtures.

2 and 5 footcandles, with an average of 3 footcandles. The power consumption would be 0.6 watts per square yard.

7.3.2.2 High Mast Perimeter Pier Lighting. On narrow piers; i.e., under 120 feet wide, with high industrial activity levels or major ship overhang problems, high mast perimeter lighting using pole-mounted power spots and wide beam floodlights, positioned at the ends of the pier and midpoints between berths, may provide the best illumination alternative.

Banks of lights consisting of 400-watt HPS power spots and 400-watt or 1000-watt HPS wide beam floodlights, mounted on 100-foot poles, would be required for a pole spacing of 600 feet. Using five or six poles as shown in figure 7-4, with different aiming points for each luminaire, will provide an average lighting level of 3 to 6 footcandles in the working area depending upon the number of fixtures employed. Shields would be used to prevent or minimize glare.

Figures 7-5 and 7-6 provide standard illumination diagrams for two lamping configurations of high mast perimeter lighting on a 1200-foot long by 80-foot wide pier using five 100-foot poles as shown in figure 7-4.a. A maintenance factor of 0.85 is used to provide adjustment for luminaire deterioration and dust. Five poles are recommended, in lieu of six poles,in order to reduce cost and avoid having poles on the outboard corners where they might be hit by a ship entering the outboard slip. In summary:

- Figure 7-5 shows utilizing forty-eight 400-watt HPS fixtures or 24 fixtures per 600-foot by 80-foot array. With this configuration, lighting levels vary between 1.5 and 11.5 footcandles, with an average lighting level of 6.67 footcandles. Overall lighting will be more than adequate with reasonably good uniformity. The power requirements would be 1.8 watts per square yard.

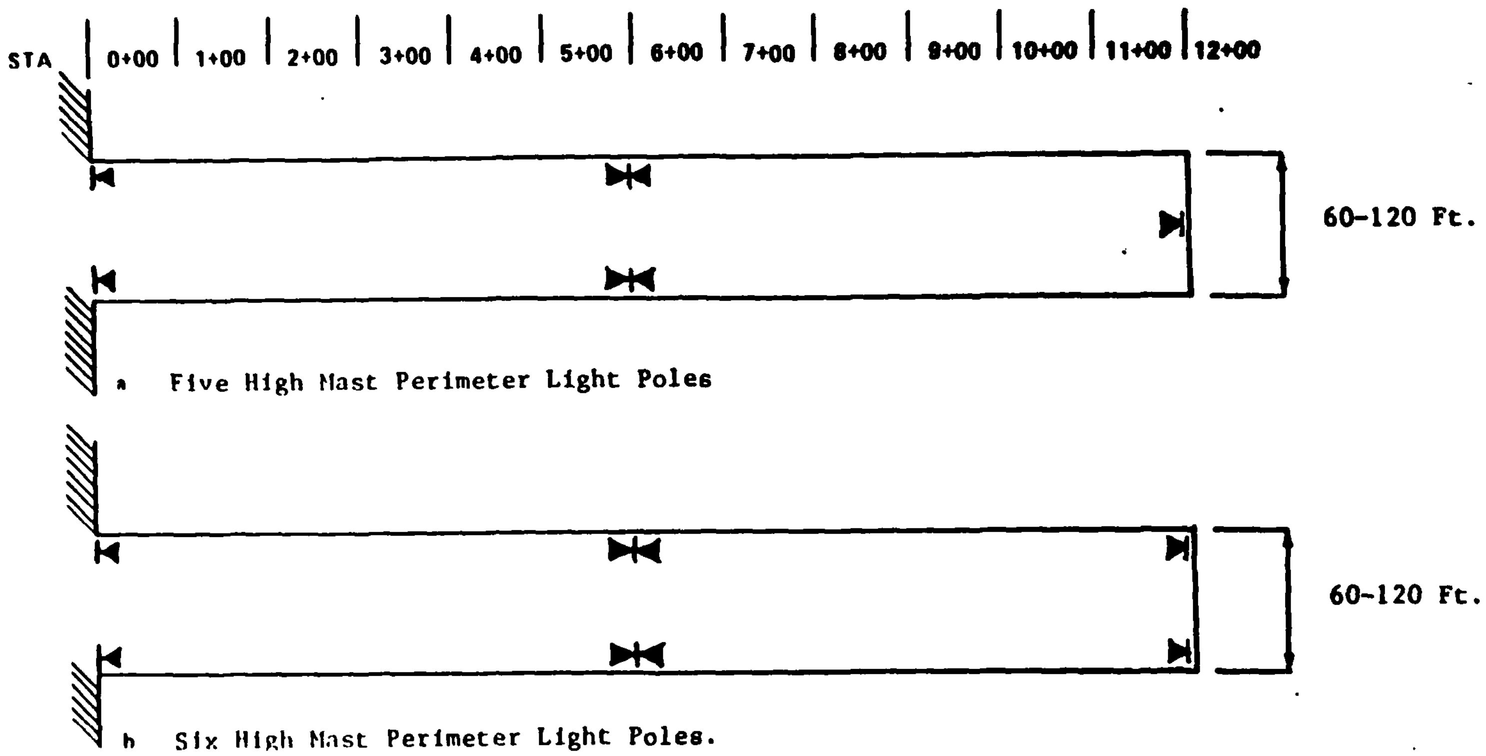
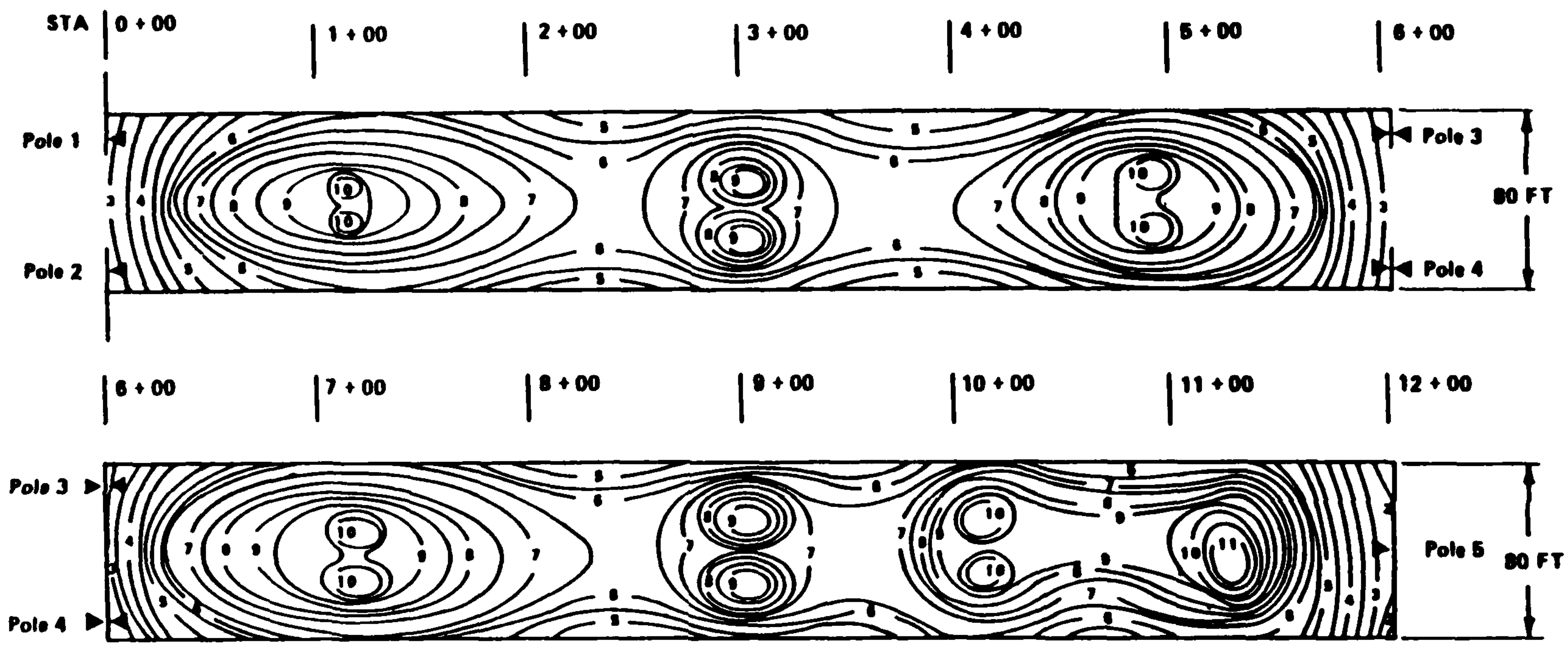


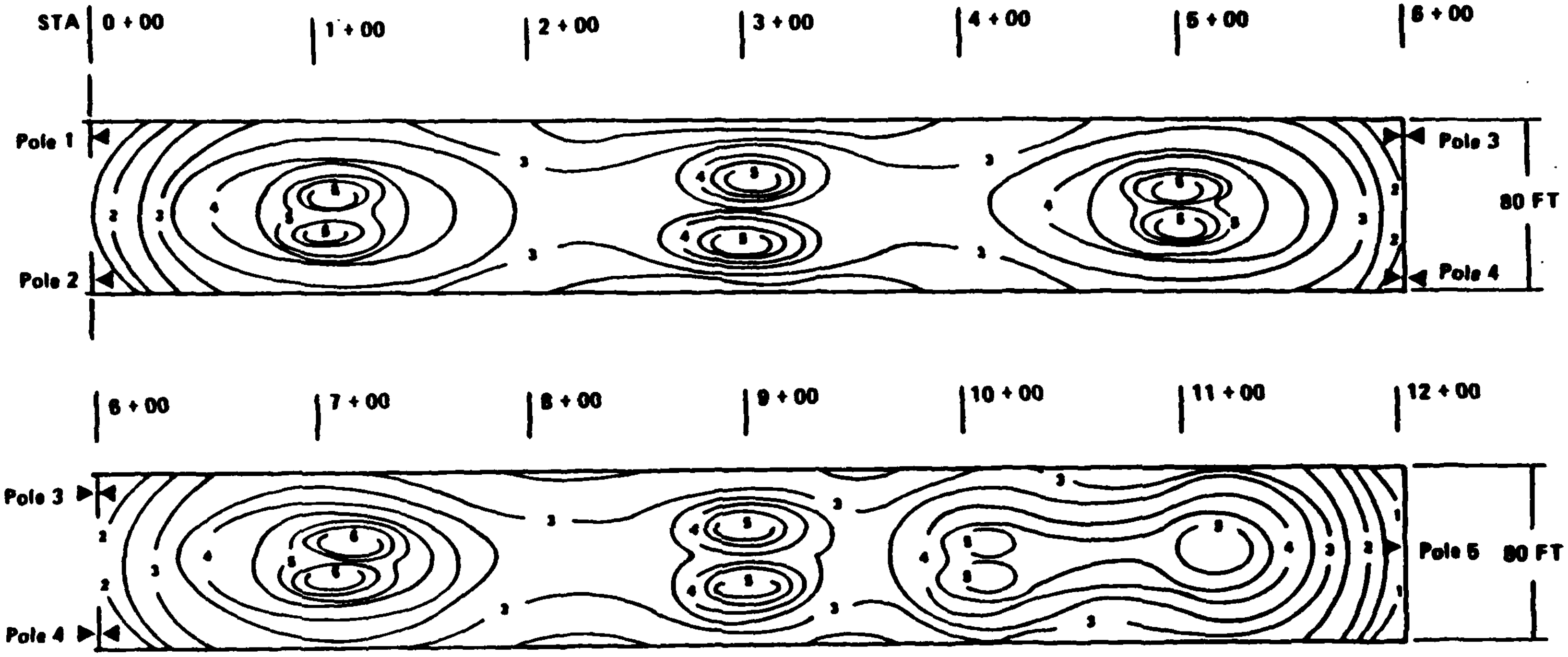
Figure 7-4. Recommended Perimeter Lighting Using High Mast Poles and Floodlight Fixtures.



Poles 1 & 2 : **Five 400 Watt NEMA 2X2 HPS and One 400 Watt NEMA 4.X 4 HPS Power Spot Floodlights .**

Poles 3,4 & 5 : **Six 400 Watt NEMA 2 X 2 HPS and Two 400 Watt NEMA 4 X 4 HPS Power Spot Floodlights .**

Figure 7-5. Standard Illumination Diagram, in Footcandles, 1200-Foot Long by 80-Foot Wide Pier, Using 48 Floodlight Fixtures on Five 100-Foot Poles.



Poles 1 & 2 : Three 400 Watt NEMA 2 X 2 HPS and One 400 Watt NEMA 4 X 4 HPS Power Spot Floodlights.

Poles 3,4 & 5 : Six 400 Watt NEMA 2 X 2 HPS and Two 400 Watt NEMA 4 X 4 HPS Power Spot Floodlights.

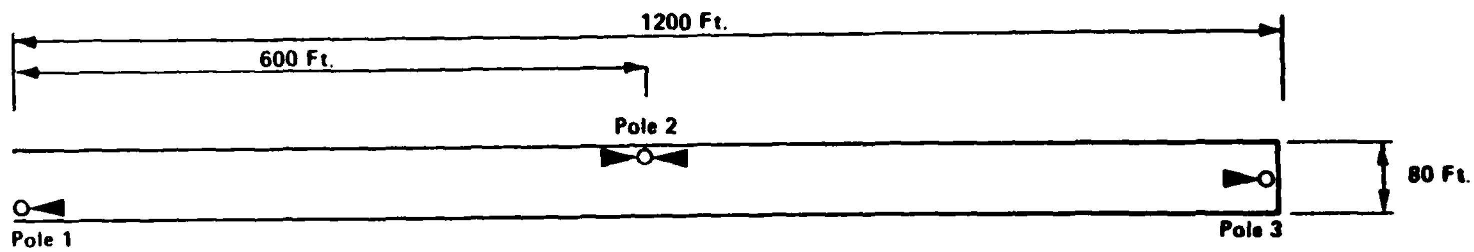
Figure 7-6. Standard Illumination Diagram, in Footcandles, 1200-Foot Long by 80-Foot Wide Pier, Using 32 Floodlight Fixtures on Five 100-Foot Poles.

- Figure 7-6 provides a lower illumination level utilizing thirty-two 400-watt HPS fixtures, or 16 fixtures per array. With this configuration, lighting levels vary between 1.5 and 6 footcandles, with an average of approximately 4.4 footcandles. Overall lighting will be adequate with reasonably good uniformity. The power requirement would be 1.2 watts per square yard.

Where piers are very narrow; i.e., under 90 feet wide, the option may also exist to use only three poles, as shown in figure 7-7, thereby, reducing construction cost by 35% to 40%. The use of three poles will require aiming luminaires across the pier to the outside berth; however, with 100-foot mounting heights for fixtures, glare should not be a problem. Figure 7-8 provides a standard illumination diagram for a 1200-foot long by 80-foot wide pier using three 100-foot poles and a maintenance factor of 0.85. Lighting levels will vary between 1 and 8 footcandles, with an average of 4.43 footcandles. Overall lighting will be adequate with reasonably good uniformity. The power requirement would be 1.2 watts per square yard.

Figure 7-9 provides a standard illumination diagram for a 1200-foot long by 120-foot wide pier using five 100-foot poles and a maintenance factor of 0.85. This configuration uses forty-eight 400-watt HPS fixtures, or 24 fixtures per 600-foot by 120-foot array. Lighting levels vary between 1.7 and 8 footcandles, with an average of 5.07 footcandles. Overall lighting will be excellent with good uniformity. The power requirement would be 1.2 watts per square yard. Again, glare in the direction of the ship would be minimized or eliminated by the use of shields.

The selection of the type of lighting standard to be used in any high mast perimeter lighting design will be affected by the environmental conditions; i.e., winds and salt sprays, maintenance requirements for care and

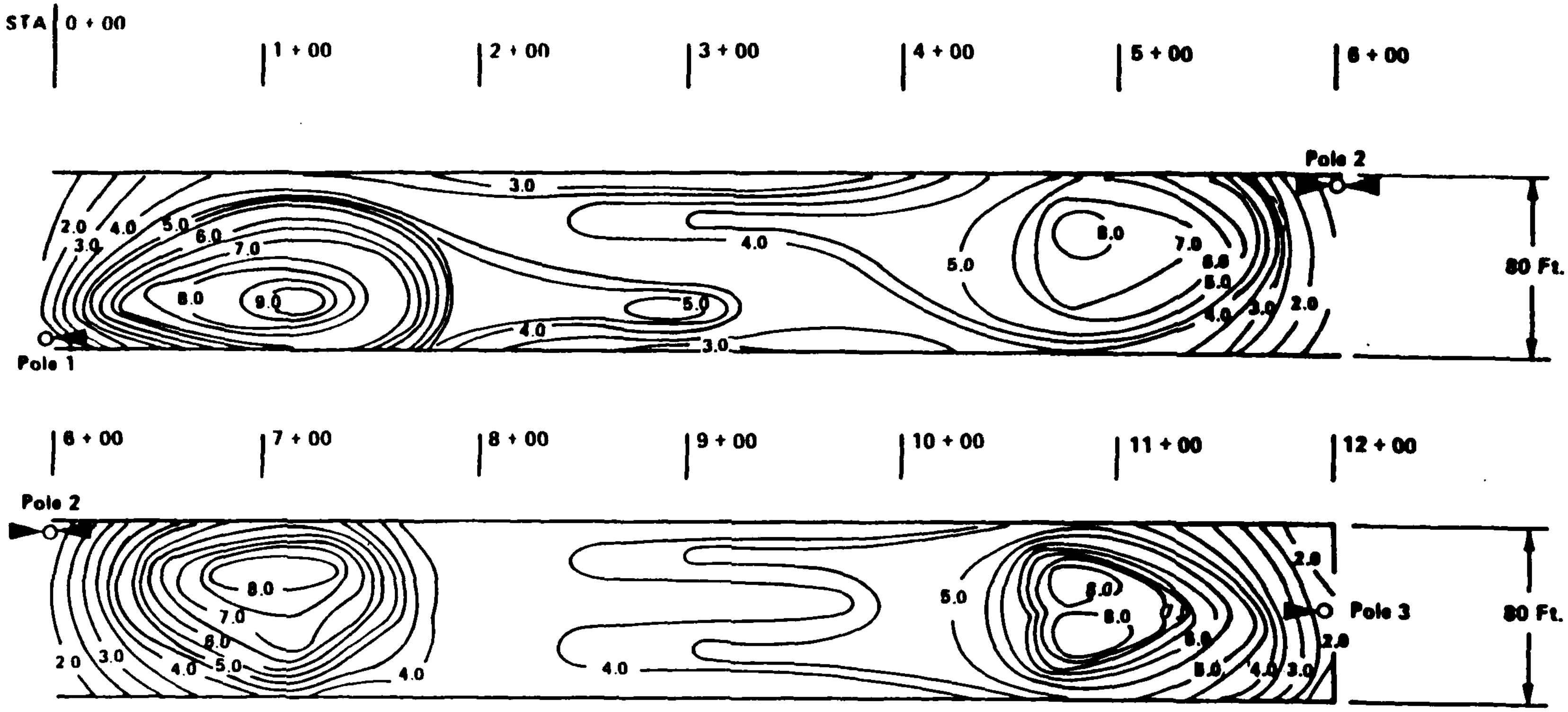


POLE LIGHTING ASSEMBLIES :

Poles 1 & 3 : Six 400 Watt NEMA Type 2 X 2 and Two 400 Watt NEMA Type 4 X 4 HPS Fixtures on 100 - Foot Poles.

Pole 2 : Twelve 400 Watt NEMA Type 2 X 2 and Four 400 Watt NEMA Type 4 X 4 HPS Fixtures on 100 - Foot Pole.

Figure 7-7. Alternate Perimeter Lighting Using Three High-Mast Poles and Floodlight Fixtures.

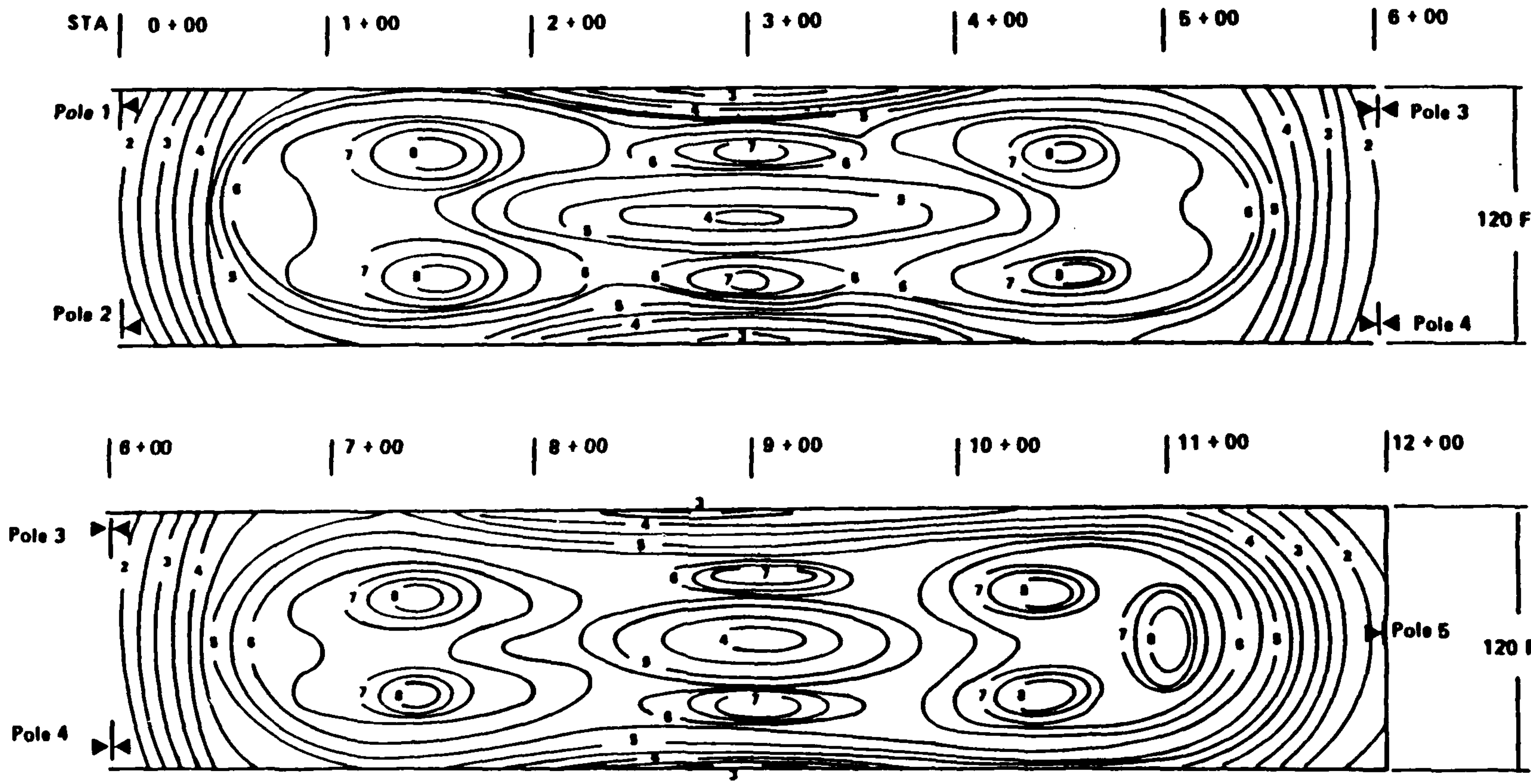


Pole Lighting Assemblies:

Poles 1 & 3: Six 400 Watt NEMA Type 2 X 2 and Two 400 Watt NEMA Type 4 X 4 HPS Fixtures on 100- Foot Poles.

Pole 2 : Twelve 400 Watt NEMA Type 2 X 2 and Four 400 Watt NEMA Type 4 X 4 HPS Fixtures on 100 - Foot Poles.

Figure 7-8. Standard Illumination Diagram, in Footcandles, 1200-Foot Long by 80-Foot Wide Pier, Using 32 Floodlight Fixtures on Three 100-Foot Poles.



Poles 1 & 2 : Five 400 Watt NEMA 2 X 2 HPS and One 400 Watt NEMA 4 X 4 HPS Power Spot Floodlights.

Poles 3,4 & 5 : Ten 400 Watt NEMA 2 X 2 HPS and Two 400 Watt NEMA 4 X 4 HPS Power Spot Floodlights.

Figure 7-9. Standard Illumination Diagram, in Footcandles, 1200-Foot Long by 120-Foot Wide Pier, Using 48 Floodlight Fixtures on Five 100-Foot Poles.

preservation of the hardware, and relamping requirements. The latter requirement, relamping, may ultimately dictate the type of pole to be installed on the pier. This is partially borne out by the problems being experienced obtaining suitable equipment to relamp the high mast fixtures. Considering all potential factors, use of high mast poles with lowerable hoist/fixture rings, as shown in figure 7-10, may be more cost effective.

7.3.2.3 Centerline Pier Lighting. For piers 125 feet wide or greater, centerline lighting may provide the best solution.

Using four 1000-watt HPS downlight fixtures on 80-foot poles, spaced 200 to 250 feet on-centers down the centerline of the pier, as shown in figure 7-11, should produce lighting levels of 3.5 to 5.5 footcandles in the working areas. Figures 7-12 and 7-13 provide standard illumination diagrams for the 80-foot poles spaced either 200 feet on-centers or 250 feet on-centers, using a maintenance factor of 0.85 to provide adjustment for luminaire deterioration and dust. The pole design would be similar to that shown in figure 7-10, except downlights are used instead of floodlights. The average illumination levels obtained with these designs, are:

- 4.3 footcandles for 200-foot spacing.
- 3.8 footcandles for 250-foot spacing.

Overall uniformity of light patterns should be good. Glare should be nonexistent.

The use of 100-foot poles would not normally be recommended for centerline lighting unless the requirement existed to provide increased lighting on ship decks. The purpose for using the 100-foot poles is to obtain a wider and higher distribution pattern with lower lighting intensity per unit surface area. Compensation for the lower lighting levels can be provided by using

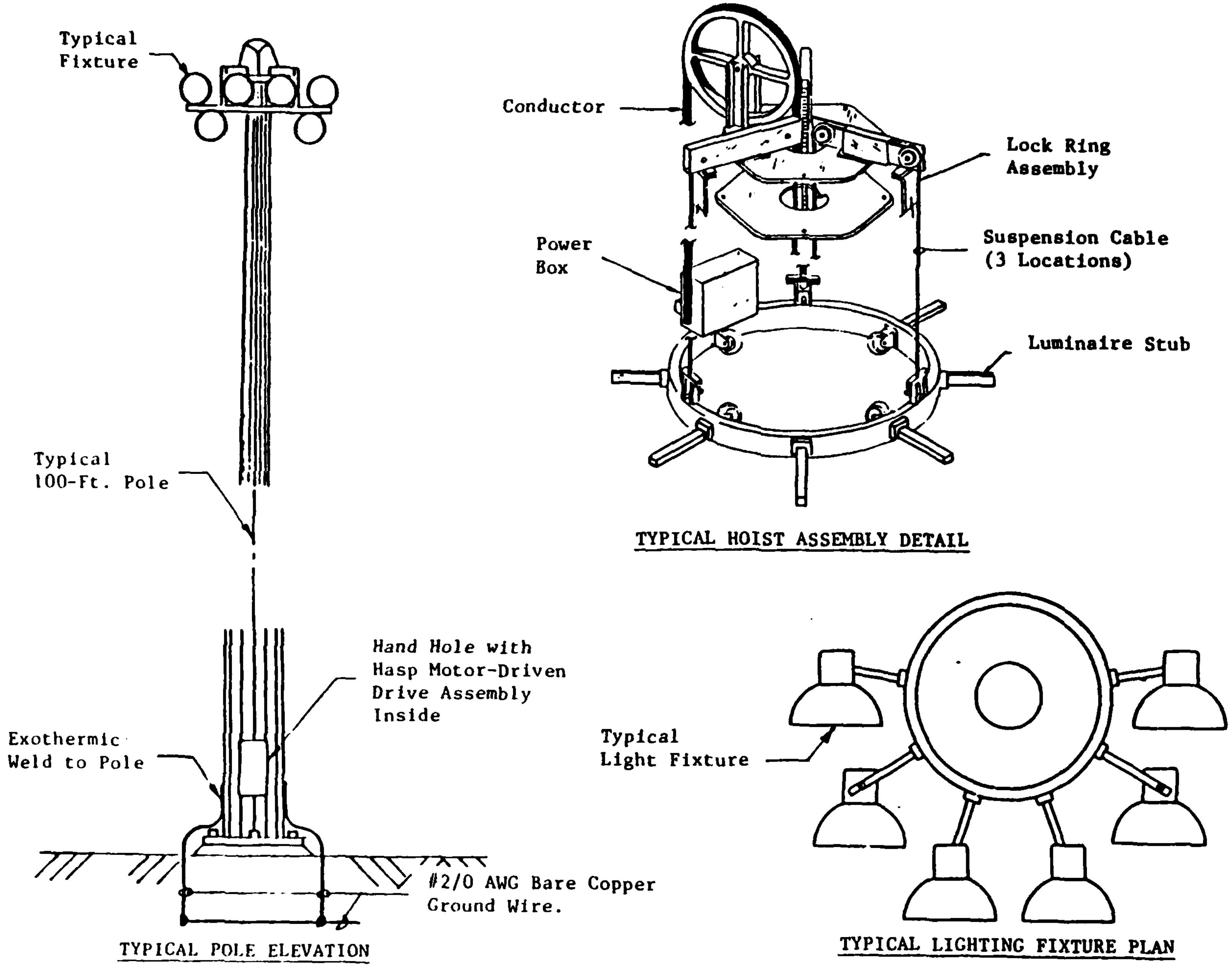


Figure 7-10. Typical High Mast Light Pole with Floodlight Fixtures and Lowerable Hoist Ring.

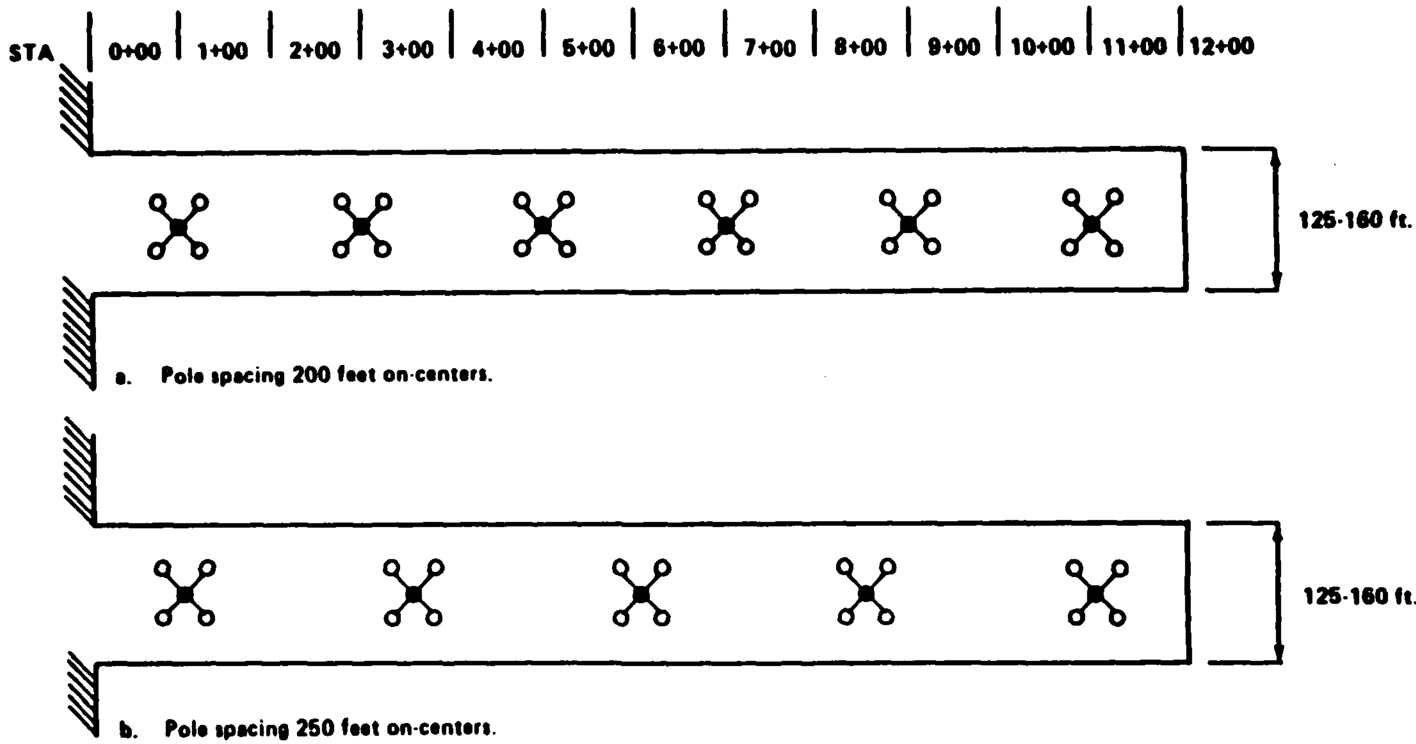


Figure 7-11. Recommended Centerline Lighting Using Four 1,000-Watt HPS Downlight Fixtures per Pole.

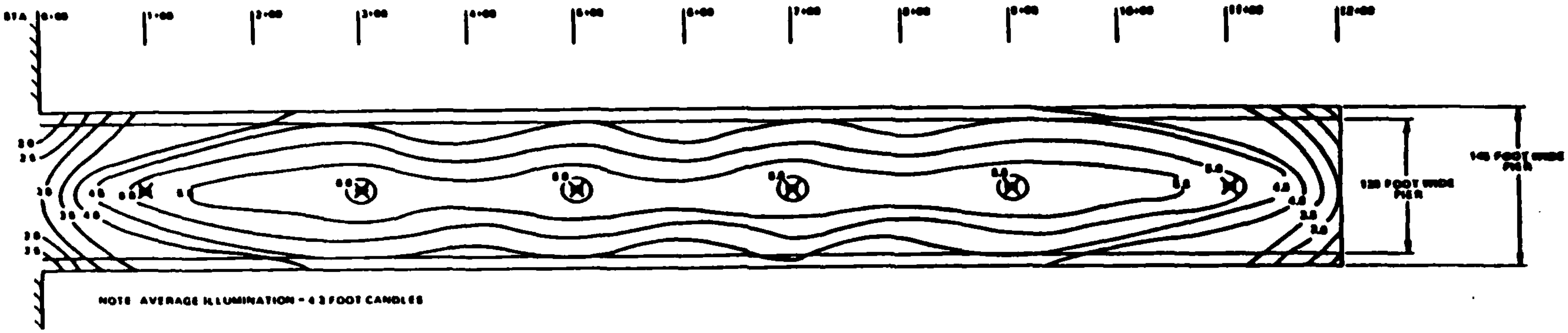


Figure 7-12. Standard Illumination Diagram, in Footcandles, Using Four 1,000-Watt HPS Downlight Fixtures on 80-Foot Poles, Spaced 200 Feet On-Centers.

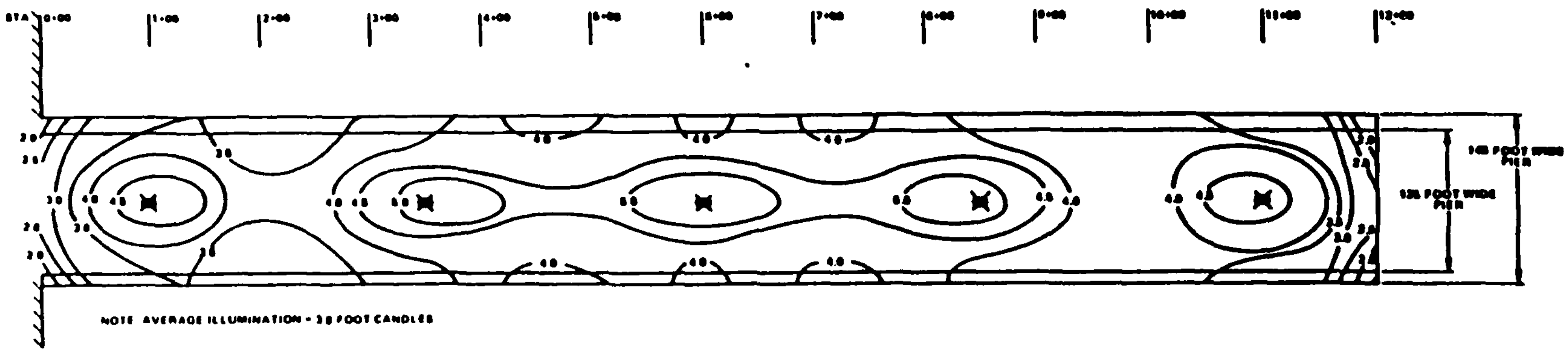


Figure 7-13. Standard Illumination Diagram, in Footcandles, Using Four 1,000-Watt HPS Downlight Fixtures on 80-Foot Poles, Spaced 250 Feet On-Centers.

six 1000-watt HPS fixtures per pole versus four. Figure 7-14 provides a comparison of the two versions using 100-foot poles spaced 250 feet on-center.

The overall power consumption to provide the 3.5 to 5.5 footcandles illumination levels for a 1200-foot long by 145-foot wide pier, using 80-foot poles, would be 1.03 watts per square yard for pole spacing of 250 feet on-center, and 1.24 watts per square yard for pole spacing of 200 feet on-center.

The location of the lighting poles, 62.5 feet (plus) inboard of the pier face, should not cause interference with pier operations. This conclusion is based upon the following single berth width requirements:

4 feet - outer width for curb, bollards, and mooring lines
12 feet - utility area
30 feet - unobstructed crane area
15 feet - fire lane
61 feet - total single berth width

On wider piers, the centerline of the pier may be dedicated to storage and/or parking which would interface well with the centerline lighting plan.

7.4 Recommended Lower Deck Lighting

Recommended lower deck lighting is provided by fluorescent fixtures supported from the underside of the upper deck. Approximately 60 fixtures would be required for a deck area 1200-foot long by 80-foot wide, to provide adequate illumination levels in the various work areas, electrical equipment vaults and vehicular passage ways. Wiring is routed in PVC-coated, galvanized steel conduit. Vapor and waterproof housing for light fixtures is seam-welded stainless steel. The light diffuser consists of a high-impact resistant polycarbonate lens. Lampholders are spring loaded, shock and vibration resistant. Lamp ballasts are high power factor 1500 milliamp rated at -20°F service.

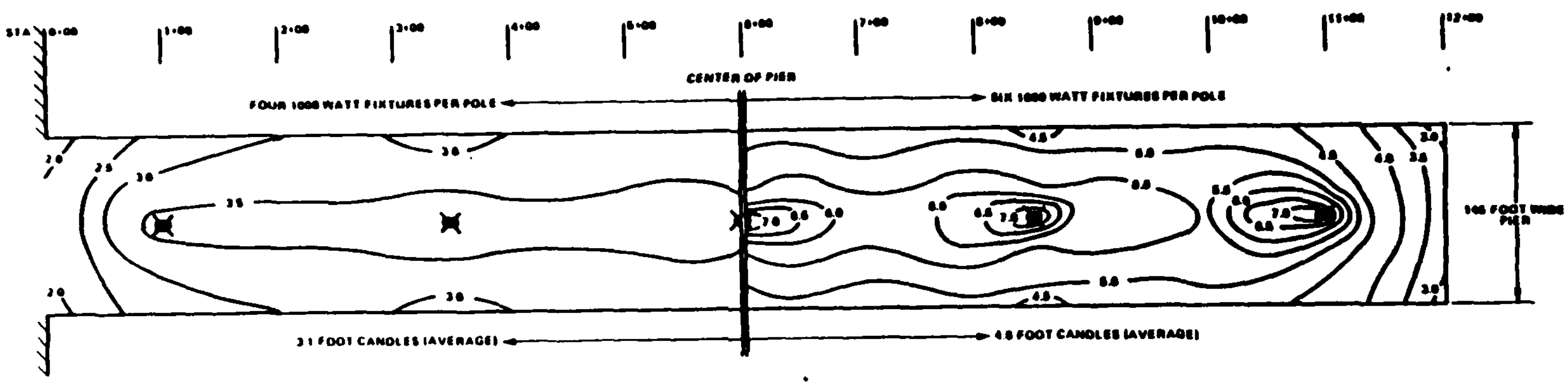


Figure 7-14. Standard Illumination Diagram, in Footcandles, Using Four 1,000-Watt HPS Downlight Fixtures, or Six 1,000-Watt HPS Downlight Fixtures on 100-Foot Poles, Spaced 250 Feet On-Centers.

7.5 Reference

The material contained in this section has been extracted from the following documents:

- NCEL CR 83.032, Conceptual Designs for Berthing Pier Galleries and Deck Lighting, Brown & Root Development, Inc., June 1983.
- VSE Report, Navy Pier Lighting Investigation, January 1985.

SECTION 8

DECK FITTINGS

DM 25.1 specifies 60 feet as the recommended spacing along the berthing face in order to provide the number of fittings required to secure the ships.

Observations of newest designs being employed indicate an increased shift to 75 or 80 feet for bollard spacing on piers located within generally protected harbor areas. In the case of one pier constructed in 1980, no problems were identified during discussions with fleet units relative to the use of bollards 75 feet-on-center versus 60 feet-on-center.

8.1 Bollard Spacing

The selection of bollard spacing should be primarily a function of ship line patterns. In generally protected harbors, it is recommended that the line patterns for each ship class be laid, one over the other, in order to determine the optimum bollard spacing. In many cases, 75 to 80 foot spacing may be adequate, thereby improving upon the "clear" deck concept.

8.2 Double-Deck Piers.

With the introduction of the double-deck pier, either fixed or floating, bollard and cleat spacing takes on a new dimension.

As a general recommendation, bollards would appear to be best located on the main deck with the smaller cleats located on the lower level, as shown in figure 8-1. In most instances, the ship's bow mooring chocks will be 2 to 14 feet higher than the 20 foot main deck height, which would decrease the angle of the mooring line between the ship and the pier, in comparison to existing pier heights. Dependent upon tidal conditions, the stern chocks will vary from -4 feet to +3 feet in relation to the 20 foot main deck height. For

mooring lines that would project downward from the bollard to stern chocks, an interface profile should be drawn to study the line orientation to ensure that scuffing and damage to the lines do not occur. Small craft and barges which might use the pier may best be served by cleats from the lower deck, rather than by the bollards.

The layout shown in figure 8-1 is typical of the new pier ZULU design being constructed at the Naval Station, Charleston, SC.

8.3 References

The material contained in this section was extracted from the following documents:

- VSE Report, Pier Utilization Study for Small and Medium Surface Combatants, September 1983.
- Gee & Jenson, Plans and Specifications, Berthing Pier (MILCON Project P-135), Naval Station, Charleston, SC, 7 November 1983.

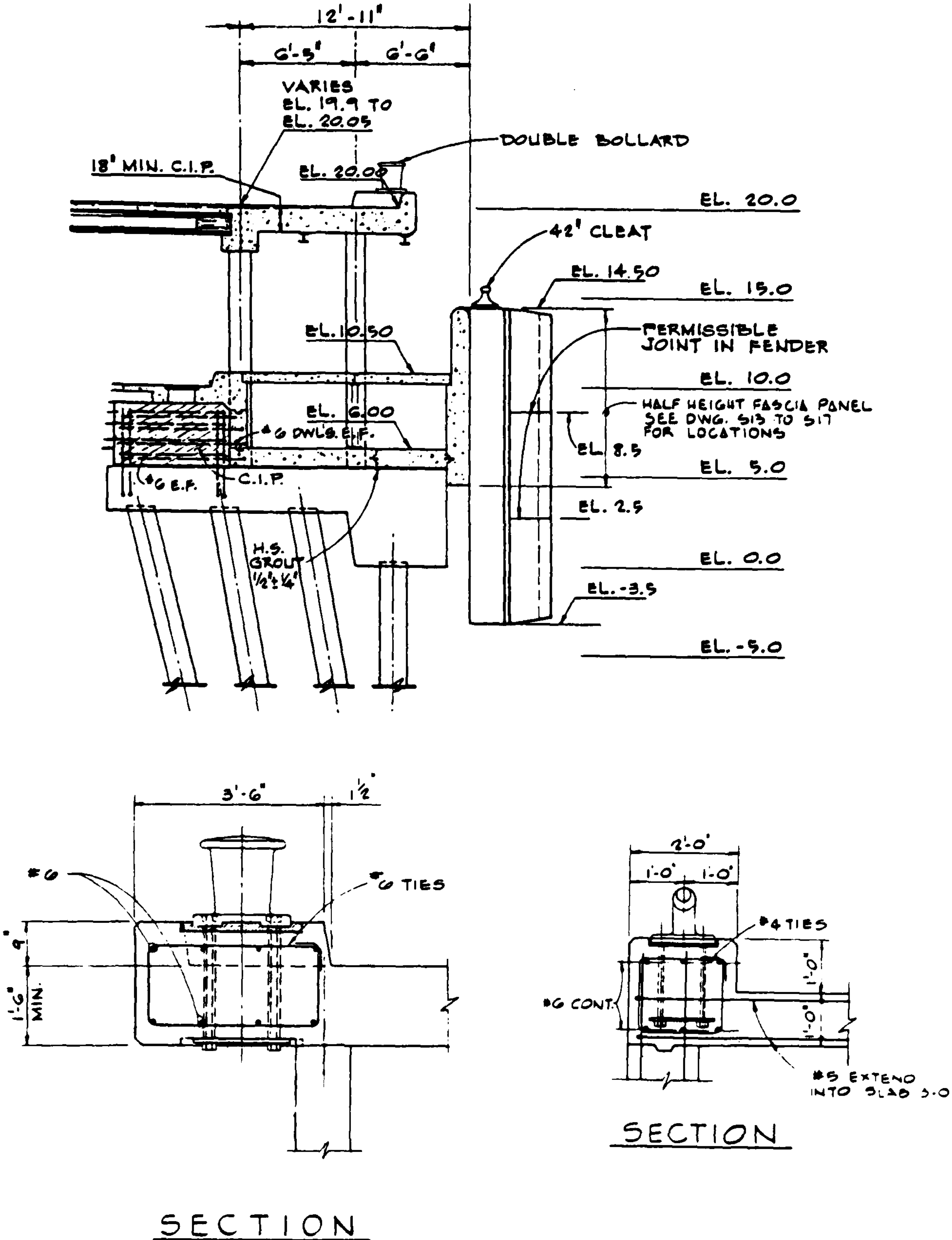


Figure 8-1. Pier Elevation and Sections Showing Locations of Bollards and Cleats.

SECTION 9

ACCESS FACILITIES

The current methods of providing personnel access normally involve use of a mobile crane and 5 to 9 people to set a brow and platform. This operation, including "dead time" for the crane, frequently exceeds one hour and adds substantially to the congestion on the pier. When not in use, the brows and platforms are normally stored on the pier, also adding to the overall congestion.

The use of brows with platforms, while being acceptable for use during good weather and lighted conditions, may impose a safety problem on poorly lighted piers or during inclement weather conditions.

The transfer of ship's stores is also frequently accomplished by hand-carrying the stores over the brow and platform. This type of loading operation is very time consuming and labor intensive, and frequently takes up critical space on the pier. The alternative of using a crane is even worse when viewed relative to equipment use and pier congestion.

The development of improved pier designs, therefore, brings an opportunity to change and improve the methods for providing both personnel access and transfer of ship's stores.

9.1 Brows and Platforms

With the introduction of the double-deck pier and a main deck height of 20 feet, many platforms could be eliminated for a number of ship classes with brows alone serving the purpose. More brows can then be placed manually, or with the use of a light duty mobile hydraulic crane. More important, though, the new pier designs will provide an opportunity to design a new and different "system" for personnel access.

The following steps should be taken with each new pier design:

- With each conceptual or definitive pier design, specifically determine horizontal and vertical dimensions and orientations of access equipment for several typical tidal ranges; say a low, medium and high, and for the types/classes of ships to be berthed.
- Determine the size of the brows and platforms that will be required. Review MIL-B-22342, Brows, and MIL-P-232120, Platforms, and propose changes as required to these specifications.
- Include the design of access equipment, or the adaptation of standard designs, in the final design contracts for new berthing piers.

9.2 Conveyors

The use of small mobile or portable conveyors, similar to those used for loading baggage onto aircraft, could significantly reduce manpower and time requirements, and eliminate many of the safety hazards associated with personnel hand carrying stores over a brow and platform.

With each new pier design, the activity should:

- Evaluate the volume of stores to be loaded on each ship class to be berthed at the pier including manhour and time requirements, equipment involved, etc.
- Investigate the equipment options available on the commercial market incuding both mobile and portable conveyors.
- Perform a Life Cycle Cost (LCC) analysis of each option.
- Include the cost of the conveyor in the pier project as collateral equipment, provided the LCC supports the buy action.

9.3 Reference

The material contained in this section was extracted from the following document:

- VSE Report, Pier Utilization Study for Small and Medium Surface Combatants, September 1983.

SECTION 10

PIER DESIGN EVALUATION

The selection of any pier design concept becomes a function of anticipated long term use, utility benefit to the fleet, and life cycle costs. The designs to be evaluated must be feasible, practical, and meet basic structural design parameters. Only qualified designs should be evaluated, so that one compares performance, efficiency, and cost of equal alternatives.

This section provides a methodology and structured system for evaluation and comparing pier designs.

10.1 Life Cycle Cost Analysis

The LCC analysis of each alternative needs to consider:

- Acquisition cost including:
  - Mobilization
  - Dredging
  - Pier structure
  - Piling
  - Fender systems
  - Utilities
  - Abutments and ramps
- Pier operational cost including:
  - Cost to place and remove brows and platforms
  - Cost to provide crane services for ship maintenance and repair functions
  - Cost to load cargo onboard a ship
- Maintenance and repair requirements to include:
  - Maintenance dredging

- Inspection and repairs to pier structure, piling and fender systems.
- Inspection, maintenance and repairs to electrical distribution systems and service outlets, mechanical systems, fire alarm systems, and cathodic protection systems.

• Terminal value of the pier at the end of a predetermined period of time.

The Naval Facilities Engineering Command Economic Analysis Handbook, NAVFAC P-442, should be used to perform the analysis. A 10 % discount factor should be assumed; and a life expectancy of 25 years is recommended. The 25-year time factor is based more upon the ability to predict fleet requirements into the future than upon a structural evaluation of the pier itself.

Following the development of individual LCC factors for each alternative, sensitivity analyses should be performed to test for the impact upon the overall net present value costs resulting from potential variances to the factors used in the calculations.

Appendix C provides a typical comparison of a floating pier and pile-supported pier accomplished at NCEL in early 1984. Even though the frequency and cost factors used for this specific example may not be applicable at other locations and cases, the general approach provides a valid methodology for comparing alternatives using LCC analyses.

10.2 Pier Design Evaluation System

In addition to LCC analyses of different alternatives, other factors that can dramatically affect fleet support should also be considered in the selection of a pier design. While these factors cannot be quantified directly, means are available to evaluate them subjectively and to assign weight factors for purposes of scoring alternatives as to utility benefit.

Appendix D provides a Pier Design Evaluation System for comparing performance of pier designs using the following factors:

BERTHING

- Capacity
  - -- Ships at berth
  - -- Nesting capacity
- Utilization of Area
  - -- Water area
  - -- Land area
- Restraint System
  - -- Compatible with line patterns
  - -- Tie-up time
- Fendering
  - -- Effectiveness
  - -- Life expectancy
  - -- Ease of Repair
  - -- Eliminates camels

PIER CONFIGURATION

- Clear Usable Deck Space
- Main Deck elevation
  - -- Relative to mean low water
  - -- Relative to mean high water
- Ship Arrival/Departure
  - -- Tugs required
  - -- Safety of approach
- Heavy Lift and Load Services

UTILITIES

- Connect/Disconnect
  - -- Time/labor required
  - -- Safety
  - -- Spill protection
- Efficiency of Supply Locations
- Accessability/Ease of Maintenance
- Protection from Damage
- Expansion Potential

CONSTRUCTION

- Compatible with Current Construction Methods
- Time
  - -- Total construction time
  - -- On-site time

UNIQUE DESIGN FEATURES

These factors are scored based on measurements when available, estimates, analysis, and judgement. The scores are weighted based upon the relative importance assigned each factor. A numerical rating based on a 10-point scoring system results from this evaluation.

With the availability of both LCC and subjective benefit analyses, the cost estimates can be analyzed in various ways to compare the benefits and costs of alternative designs. One method includes comparing:

- Acquisition Cost to Evaluation Rating
- Annual Cost to Evaluation Rating
- LCC to Evaluation Rating

This would permit an evaluation of the capabilities of the design as a function of cost; i.e. the cost to provide one unit of capability or utility. Other methods include comparing the Evaluation Rating to Acquisition Cost, Annual Cost, and LCC to show how much capability or utility is obtained with each unit of cost.

In any selection of a pier design, as many costs and benefits should be considered as possible provided adequate information is available to support a fair comparison of the alternatives.

10.3 References

The materials contained in this section and appendices C and D, were extracted from the following documents:

- VSE Report, Pier Design Evaluation System, December 1983.
- Brown & Root Development Inc. Report, Floating Pier Concept, Preliminary Engineering Studies and Preliminary Construction and Life Cycle Cost Estimate at Pier 92, Port of Seattle, Washington, December 1983.
- VSE Report, Life Cycle Cost Comparison of Navy Floating Pier and Fixed Pile-Supported Pier, January 1984.

SECTION 11

NCEL PORT SYSTEM PROJECT

The basic objective of the NCEL Port System Project is to advance the pier design concepts supporting both new pier designs and renovation of existing piers.

The RDT&E approach in developing the Port System Project continues to be influenced by the Fleet, EFDs, and Naval shore activities from inputs received from the Pier Design Workshops and Conferences held at NCEL. Within funding constraints, NCEL has taken the recommendations received from the conferences and workshops and incorporated them into the various subprojects in order to program the RDT&E efforts.

11.1 Pier Design Conference Recommendations

As part of the Naval Facilities Engineering Command/Naval Civil Engineering Laboratory (NAVFACENGCOM/NCEL) Pier Design Project, a Pier Design Conference was held in February/March 1984 to:

- Review current pier MILCON projects at Treasure Island, Charleston, and Staten Island.
- Evaluate new design concepts for surface combatants developed to date, recommend new or changed project direction, and recommend priorities of work for the project.
- Develop strategy and action items for the implementation of improved pier design concepts.

This conference was a follow-on to the Pier Design Workshop held in February 1981, which set the initial guidelines and priorities for the project.

Representatives of CINCLANTFLT, CINCPACFLT/COMNAVSURFPAC, NAVSTA Mayport/Norfolk/Charleston/San Diego/Treasure Island, NSWSES, NAVFACENGCOM Headquarters, NAVFAC Engineering Field Divisions and Public Works Centers attended.

The conference generally endorsed the work accomplished in the Pier Design Project with two major additions/changes in direction summarized below. Excellent input and recommendations were provided on a number of pier design and berthing support aspects.

Major conclusions and recommendations:

- Many existing piers now providing marginal or inadequate support will be used by newer, more complex ships for decades to come. The level of support will continue to decrease due to facility constraints. Major improvements to the better existing piers have a higher priority than work on new designs for new piers.
- Develop feasible and economical design concepts for the improvement of typical existing piers. Concentrate on retrofitting modern fender systems, pier lighting, optimum location of utility outlets, below deck transformer vaults, unrestricted crane areas, and deck widths.
- In addition to surface combatant ships, piers must be capable of supporting amphibious ships and certain types of service ships. This multitype capability is necessary to provide flexibility within a port and to ensure adequate berthing suppot to amphibious and service ships.
- Add selected types of amphibious and service ships to the Pier Design Project. Develop ship requirements and overlay on pier design concepts to determine feasibility of designing for all three groups of ships.

- Ship phased maintenance activities (PMA) conducted at berthing piers will increase at a number of homeports. New pier designs and upgrade of existing piers should accommodate PMA requirements at those ports where significant maintenance activities will be conducted.
- Develop pier requirements (space, utilities, crane service, etc.) to support PMA, translate the requirements to design criteria and promulgate for use.
- Do not revert to old general purpose pier philosophy that attempted to satisfy all ship types and was adequate for none. Continue development of design concepts and criteria that are based on specific ship requirements and pier functions.
- To advance implementation of improved pier designs, steps must be taken to: (1) verify and revise pier planning and programming documentation, (2) develop guidance and strategy for programming major upgrades of existing piers as an augment to new constructions, and (3) streamline submission and processing of MILCON projects.

Specific action items recommended by the conference, or stemming directly from the conference recommendations, included:

Improve Existing Piers

- Verify accuracy of existing pier engineering evaluations. Include performance adequacy in evaluation and obtain input from pier users.
- Include improvement of existing piers in the Pier Design Project.
- Develop planning criteria and aids for activities to guide existing pier upgrade versus replacement new construction decisions.

- Develop and promulgate complementary strategy for programming major pier upgrade projects as an augment to new construction.
- Select one or more of the more promising retrofit fender system design concepts for test and evaluation. In conjuction with selected Naval Stations and EFDs, plan installation of test sections at certain active berths as replacements for old fenders. Test and evaluate designs under actual berthing conditions.
- Fund test installations of new fender system designs as "repair by replacement" of old fenders that require major repair.
- Develop definitive drawings and guide specifications for specific recommended retrofit fender systems and promulgate.
- Participate with Naval Station, Norfolk, in test and evaluation of new pier lighting design on an existing pier.

Berthing Support for Amphibious and Service Ships

- Expand Ship Data and Berthing Requirements Book to include representative amphibious and service ship classes.
- Overlay amphibious and service ship requirements on pier design concepts and criteria being developed and determine feasibility of designing piers for increased berthing flexibility.
- Investigate adding Roll-on/Roll-off capability in pier design criteria.
- Develop modern, effective cameling that accommodates "hard-to-berth" amphibious ships.

Phased Maintenance Activities

- Develop PMA berthing pier requirements for development of design criteria. Convert input into criteria for pier designs.

- Promulgate PMA criteria to EFD's for use, where applicable, in near-term pier designs. Include criteria in NAVFAC P-80 and Design Manuals.

<u>Continued Pier Design Project Action Items</u>

- Initiate review and revision of NAVFAC P-80 to include criteria for double-deck piers, PMA requirements, etc.
- Speed up MILCON project review submittals. Have advance copies of "hot" projects sent to all in review chain simultaneously. Review written procedures for potential streamlining.
- NAVFACENGCOM liaison with NAVSEA to obtain review/changes to the Ship Data and Berthing Requirements Handbook, and continued timely input of new ship requirements.
- Develop a Guide Specification for concrete used in waterfront structures. Include lightweight concrete.
- Continue efforts to develop/establish pier salt water requirements.
- Obtain dimensions of ship bow "soft" sonar domes and include in criteria for fender and camel designs.
- Verify Ship and Berthing Reqirements Data Handbook by actual "ship check."
- Include DDG-51 data in Ship Data and Berthing Requirements Handbook.
- Prepare a detailed elevation comparison of ship mooring line locations and bollard/cleat locations in conceptual designs. Purpose is to avoid lines that slope up to the pier at an angle great enough to lift off ship bits.

- Include mechanical system freeze protection in utility gallery design development.
- Ensure conceptual designs of piers and fender systems accommodate camels for offset of ships.
- Investigate feasibility of providing access to side of ship from lower level of floating pier to remove heavy equipment through the hull.
- Evaluate explosive safety criteria as related to the double-deck pier designs.
- Evaluate the safety aspects of the double-deck pier designs; especially the hazard of the offset between the main deck and lower level.
- Construct mock-up of utility gallery and test conceptual design for efficiency, to establish dimensions and layout, etc.
- Upon completion of Pier Zulu, acquire operational data and evaluate performance of pier design relative to pier functions and service to ships.
- Develop a systems approach for design of fender systems and camels that treats the ship, camel, fender, and pier as an integral system.

11.2 Reference

The material contained in this section was extracted from the following document:

- Pier Design Conference Proceeding, February-March 1984.

APPENDIX A

SHIP DATA AND BERTHING REQUIREMENTS
FOR SMALL AND MEDIUM SURFACE COMBATANTS

1. INTRODUCTION

The ship data and berthing requirements presented in this document cover the following ship classes:

AD-41	Destroyer Tender
CG-47	Guided Missile Cruiser
DD-963	Destroyer
DDG-51	Guided Missile Destroyer
FF-1052	Fast Frigate
FFG-7	Guided Missile Fast Frigate

Based on a planned 600-ship Navy, all classes of these types of ships will represent approximately 49% of the Fleet inventory in 1992 and close to 60% by the year 2000.

The data reflected in this document covers the most current information that could be obtained from NAVSEASYSCOM drawings and publications covering the characteristics and berthing requirements of each class of ship listed. Applicable sources are covered under REFERENCES at the end of this appendix.

2.0 LOCATION SYMBOL

The location of certain physical characteristics, appurtenances and utility connections are described by a symbol comprised of the ship deck number, a frame number, and a digit indicating relationship to the ship's certerline. From the symbol, locations can be pin-pointed on the ship.

The elements of the location symbol are:

<u>Deck</u>

03 - 3rd level above main deck	1 - main deck
02 - 2nd level above main deck	2 - deck below main deck
01 - 1st level above main deck	3 - 2nd deck below main deck

<u>Frame Number</u>

Frames are numbered forward to aft beginning with frame 0 at the first perpendicular where the bow intersects the design waterline. Frames forward of the first perpendicular are designated by letter. The distance between frames varies with the type of ship as follows:

AD-41	48 inches	DD-963	12 inches
CG-47	12 inches	FF-1052	30 inches
DDG-51	Variable	FFG-7	12 inches

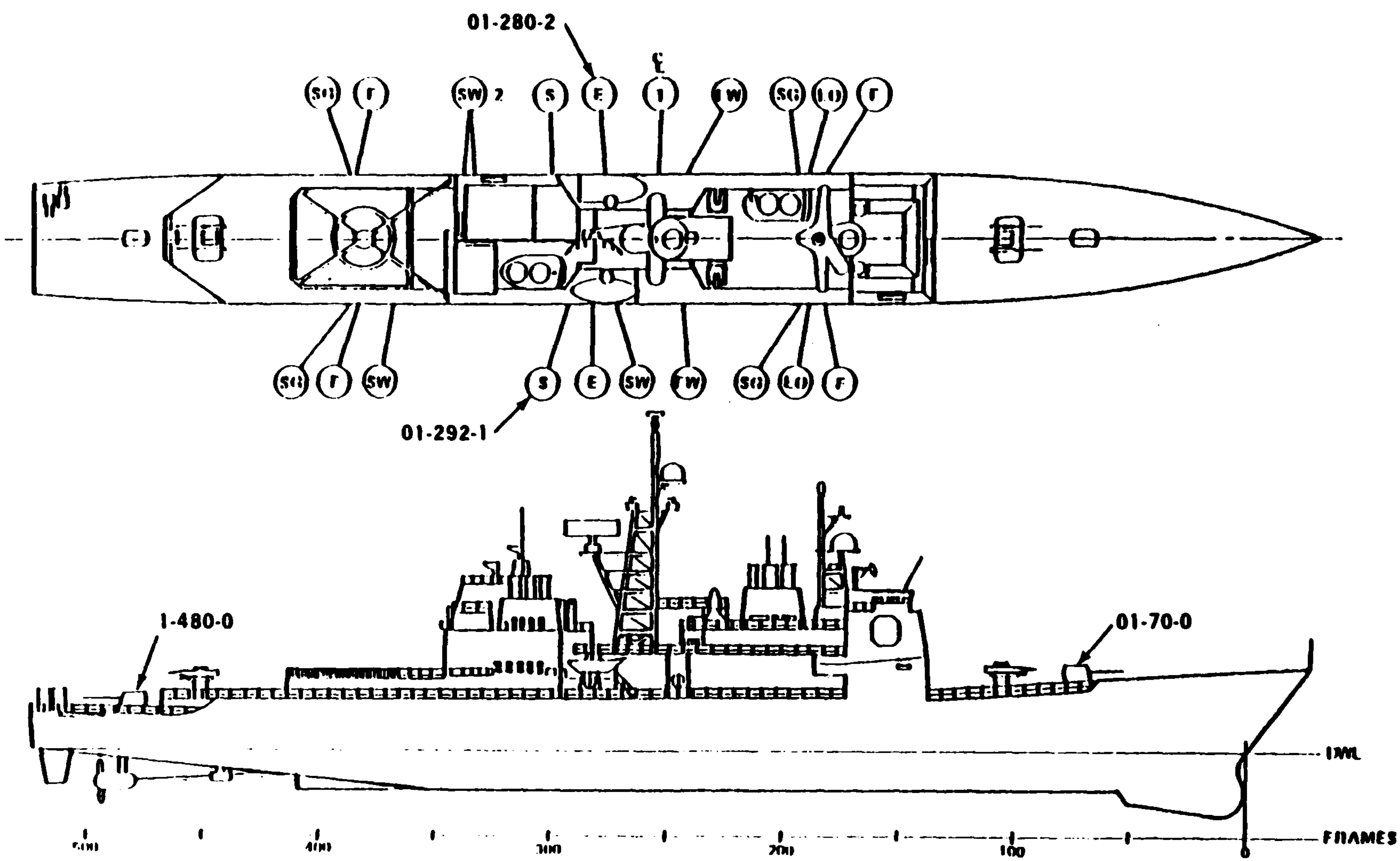
<u>Centerline Location</u>

0 = centerline (CL)
1 = starboard (right) side
2 = port (left) side

The location symbol has this form: 1 - 150 - 1

starboard side
frame
main deck

Examples are shown on the following ship plan/profile.



CG 47 GUIDED MISSILE CRUISER

3.0 SHIP PHYSICAL DATA AND UTILITY REQUIREMENTS

3.1 Data Sheets and Profile Sketches

The following pages contain:

- Table 3-1 with certain key data for 16 classes of ships. Information missing on certain ship classes was not readily available within the scope of this effort.
- Specific, more detailed physical data sheets for the five representative classes of ships chosen for this project.
- Shore utility quantity requirements and information pertinent to location and design of pier service points for the five classes of ships.
- Ship plan/profile sketches illustrating frame numbers and location of ship utility connections.

3.1.1 Utility Data. The shipboard utility connections are described with the following format:

a. Connection location symbol (see section 2.0).

b. Approximate height above design waterline.

c. Approximate distance inboard from the hull. If the connection is in the center area of the deck, it is shown "at centerline".

Connections at the same frame location on both port and starboard sides are shown as one item; e.g. 01-100-1&2. For connections on the same deck, items b. (height) and c. (distance inboard) are not repeated since the dimensions would be the same. Data not shown was not readily available within the scope of this effort.

Abbreviations for utilities used on the ship profile sketches are:

E - electrical	SW - salt water	A - compressed air	OW - oily waste
S - steam	F - fuel	T - telephone	
FW - potable water	LO - lube oil	SG - sewage	

Where a centerline symbol is shown by a utility abbreviation, the ship connection is located at the centerline of the ship.

Table 3-1. Primary Ship Physical Data.

CHARACTERISTIC	SHIP CLASS							
	AD-37	AD-41	CG-16	CG-26	CG-47	CGN-36	CGN-38	DD-931
Overall Length	641.7'	643	533'	547'	563.3'	596'	585'	418'
Maximum Beam	85'	85'	54'	54'	55'	61'	63'	45'
Maximum Draft	26.5'	26.5'	24.7'	28.7'	31'	31.5'	29'	20'
Quarterdeck Location	1-46	1-46						
Quarterdeck Height above DWL	44'	44'			24'(-)			
Forecastle - Maindeck Working Height Above DWL at Bow	44'	44'			15'(-)			
Fantail - Maindeck Working Height Above DWL at Stern	44'	44'			17'(-)			
Highest Projection Above DWL	197.5'	177.5'			138'(-)			
Full load Displacement (Tons)	20,555	22,800	7,800	7,900	9,200	10,150	11,000	4,200
Manning (number of personnel)	1,803	1,700	377	418	317	533	519	292

CHARACTERISTIC	SHIP CLASS							
	DD-963	DDG-2	DDG-37	DDG-993	FF-1040	FF-1052	FFG-1	FFG-7
Overall Length	563.5'	437'	512'	563.3'	414'	440'	414'	445'
Maximum Beam	55'	47'	52'	55'	44'	47'	44'	47'
Maximum Draft	29.5'	27.2'	23.3'	30'	24'	25'	24.2'	24'
Quarterdeck Location						01-125 or 01-152		1-190
Quarterdeck Height above DWL						15.5'		
Forecastle - Maindeck Working Height Above DWL at Bow	21'6"					24'		
Fantail - Maindeck Working Height Above DWL at Stern	17'4"					15'5"		
Highest Projection Above DWL	139'4"					122'8"		114'7"
Full load Displacement (Tons)	7,800	4,500	5,900	8,140	3,400	4,100	3,430,	3,710
Manning	296	354	377	338	247	283	248	164

PHYSICAL DATA

SHIP CLASS: AD-41 DESTROYER TENDER   Sheet 1

(all measurements in feet-inches)

Length Overall	642'
Length Between Perpendiculars (DWL)	620'
Bow Overhang from Forward Perpendicular (frame 0)	14'
Stern Overhang from Aft Perpendicular (frame 155)	8'
Breadth, Moulded Maximum	85'
Breadth, Amidships at DWL	85'
Navigational Draft	26'-6"
Lowest Projection below DWL	24'-5"
Highest Projection above DWL	177'-6"
Main Deck Height above DWL: Forward	48'-10"
Amidships	43'-6"
Aft	43'-6"
Frame Spacing	4'-0

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Quarterdeck	1	46			43'-6"
Projections:					
Propeller		148 1/2	26'-5"		
Rudder		146-149	24'		
Bilge Keel		52-103	26'-5"		
Rodmeter		59 1/2	26'-11" (at sea only)		

PHYSICAL DATA

SHIP CLASS: AD-41 DESTROYER TENDER (all measurements in feet-inches) Sheet 2

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Mooring Chocks: (port & starboard)					
Recessed Chocks		6,144			9'
Forward Chocks		A,4,9, 16			38'
2 After Chocks		152,155			22'
Boat Mooring		26			24'
4 Boat Moorings		50,78 107,124			11'
Ship Mooring Stations:					
Ten stations (5 port, 5 starboard) in side of ship used for mooring lines and as access openings for pier utility lines.	3 4 4 4 4 4	24 P&S 52 P&S 75 P 77 S 108 P&S 132 P&S			
Hull Openings:					
Material Handling Doors		65, 111			32', 38
Personnel Entrances		84, 91			22'
Machine Shop Entrance		105			22'

DATA SOURCE: NAVSEA 0905-LP-524-8020/8040/9090

SHORE UTILITY REQUIREMENTS

SHIP CLASS: AD-41 DESTROYER TENDER sheet 3

	ELECTRICAL	STEAM	POTABLE WATER
QUANTITY REQ.			
Amps/pressure	6400 amps for ship	150 psi	90 psi
Demand/Rate	4800 amps feed through		85,000 GPD
SHIP CONNECTION:			
Format:			
a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 3-100-1&2 b. 22' c. 2. a. 3-131-1 3. a. 3-126-2	1. a. 4-49-1&2 b. c. 2' 2. a. 4-106-1&2	1. a. 3-24-1&2 b. c. 2. a. 4-77-1 3. a. 4-75-2 4. a. 4-130-1&2
No. of cables/hose	16	2	
Size of cable/hose	T-400	2"	2 1/2"
Connection Type	Viking symbol 1160	Manifold with 4-2" angle valves	Relief valve 125 psi
Applicable spec.	MIL-C-24368		
MISC. DATA/REMARKS	NAVSEA Dwg. AD-41-321-4859044	AD-41-582-4860010	AD-41-582-486-0010
DATA SOURCE	NAVSEA 0905-LP-524-8040		

SHORE UTILITY REQUIREMENTS

SHIP CLASS: AD-41 DESTROYER TENDER   sheet 4

	SALT WATER	FUEL OIL	LUBE OIL
QUANTITY REQ.		F-76	
Amps/pressure	150 psi	100 psi	
Demand/Rate		600 GPM	10 GPM
SHIP CONNECTION:			
Format:			
a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 3-24-1&2 b. c. 2. a. 4-106-1&2 b. c.	1. a. 01-59-1&2 b. c. 2. a. 01-131-1&2 b. c.	1. a. 01-110-1
No. of cables/hose			
Size of cable/hose	3 1/2" hose valve with siamese connection	7"	1 1/2" portable angle valve
Connection Type			
Applicable spec.	22-N-451D-T41CEA		MIL-17331-2190
MISC. DATA/REMARKS	Dwg. AD-41-521-4859552	AD-41-544-4859828	AD-41-264-485-8952
DATA SOURCE	0905-LP-524-9010/8020	0905-LP-524 8020/9020/9030	same

SHORE UTILITY REQUIREMENTS

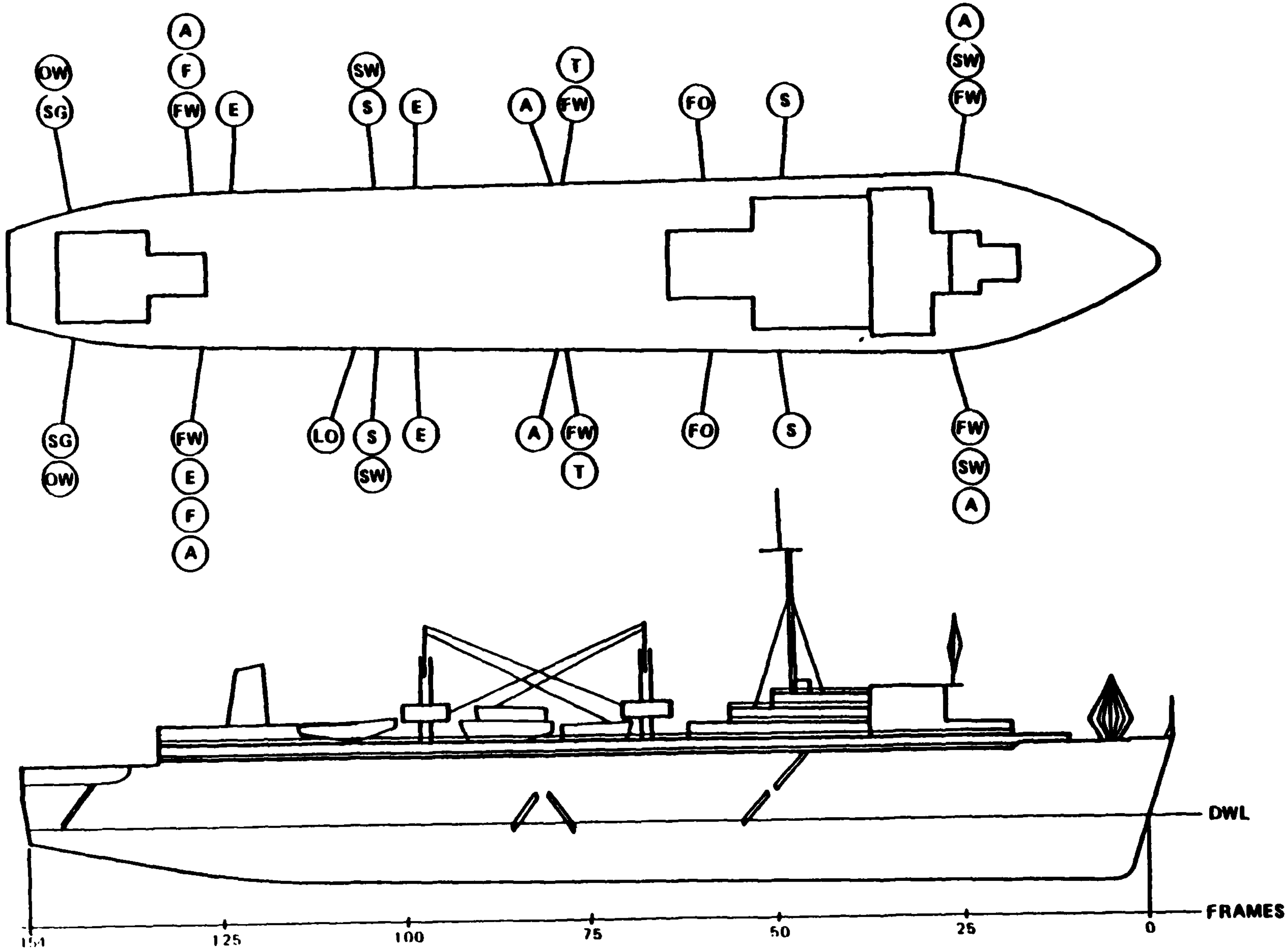
SHIP CLASS: AD-41 DESTROYER TENDER   sheet 5

	COMPRESSED AIR	TELEPHONE	DATA LINES
QUANTITY REQ. Amps/pressure Demand/Rate	100 psi		
SHIP CONNECTION: Format: a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 3-24-1&2 b. c. 2. a. 4-77-1&2 b. c. 3. a. 4-140-1 4. a. 4-131-1	1. a. 4-75-2 b. c. 2. a. 4-77-1	
No. of cables/hose		6 direct 4 trunk	
Size of cable/hose	1 1/2"	6 feed thru	
Connection Type	quick disconnect		
Applicable spec.			
MISC. DATA/REMARKS	Dwg. AD-41-551-4859898/99	Dwg. AD-41-423-4859224	
DATA SOURCE	0905-LP-524-8020/9020/9030		

SHORE UTILITY REQUIREMENTS

SHIP CLASS: AD-41 DESTROYER TENDER sheet 6

	SEWAGE	OILY WASTE
QUANTITY REQ.		
Amps/pressure	40 psi	
Demand/Rate	102,000 GPD	5000 GPD
SHIP CONNECTION:		
Format:		
a. Location Symbol	1. a. 3-148-1&2	1. a. 3-148-1&2
b. Height above DWL		
c. Distance inboard		
No. of cables/hose		
Size of cable/hose	4"	
Connection Type	Ball valve with male quick disconnect	
Applicable spec.	MIL-V-24509	MIL-N-17902
MISC. DATA/REMARKS	Dwg. 810-4444650	
DATA SOURCE	0905-LP-524-8090/9090	



AD-41 DESTROYER TENDER

PHYSICAL DATA

SHIP CLASS: CG-47 GUIDED MISSILE CRUISER (all measurements in feet-inches) — Sheet 1

Length Overall	567'
Length Between Perpendiculars (DWL)	529'
Bow Overhang from Forward Perpendicular (frame 0)	36' (est.)
Stern Overhang from Aft Perpendicular (frame 529)	2' (est.)
Breadth, Moulded Maximum	55'
Breadth, Amidships at DWL	55'
Navigational Draft	31'-7
Lowest Projection below DWL	28'
Highest Projection above DWL	138'
Main Deck Height above DWL: Forward	15'
Amidships	15'
Aft	17'
Frame Spacing	1'-0

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Quarterdeck	01	260			24'(-)
Projections:					
Sonar Dome		1-56	28'	6' from CL	
Propeller		496	25'(+)		
Rudder		511-525	25'(+)		
Bilge Keel		212-346	7'-6		
Propeller guard		482-502		27'-3 from CL	5'-5
Bulwark		0-70			19'(-)

PHYSICAL DATA

SHIP CLASS: CG-47 GUIDED MISSILE CRUISER Sheet 2
(all measurements in feet-inches)

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Air Masker Bands:					
No. 1 (pair)		296-298	All wrap	2 1/16"	3'-0
No. 2 (single)		257-258	around	2 1/16"	3'-0
No. 3 (single)		214-218	hull	2 1/16"	3'-0
No. 4 (pair)		167-172		2 1/16"	8'-0
Mooring Chocks:	01	Bow CL			
(port & starboard,	01	P			
except as noted)	01	4			
	01	22			
	01	77			
	01	132			
	01	197			
	01	278			
	01	290			
	01	390			
	01	403			
	1	498			
	1	Stern (P, S, CL)			

DATA SOURCE: NAVSEC Report No. 6116D3-406-78, August 1981

SHORE UTILITY REQUIREMENTS

SHIP CLASS: CG-47 GUIDED MISSILE CRUISER sheet 3

	ELECTRICAL	STEAM	POTABLE WATER
QUANTITY REQ.			
Amps/pressure	4000 amps	150 psi	
Demand/Rate	Type 1, 450V, 60 Hz 3-phase	9096 lb/hr.	12,000 GPD 200 GPM
SHIP CONNECTION:			
Format:			
a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 01-280-1&2 b. c.	1. a. 01-292-1 b. c. 2. a. 01-299-2 b. c.	1. a. 01-243-1&2 b. c.
No. of cables/hose	10		
Size of cable/hose	T-400		2 1/2" hose
Connection Type		Nipple thread connection	
Applicable spec.	MIL-C-24368, Receptacles		
MISC. DATA/REMARKS			

DATA SOURCE: NAVSEC Report No. 6116D3-406-78, August 1981

SHORE UTILITY REQUIREMENTS

SHIP CLASS: CG-47 GUIDED MISSILE CRUISER sheet 4

	SALT WATER	FUEL OIL	LUBE OIL
QUANTITY REQ.			
Amps/pressure		F-76: 600 GPM JP-5: 200 GPM	
Demand/Rate	1740 GPM		10 GPM
SHIP CONNECTION:			
Format:			
a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 01-274-1 b. c. 2. a. 01-371-1 3. a. 01-233-2 4. a. 01-341-2	1. a. 01-191-1 b. c. 2. a. 01-377-1 3. a. 01-184-2 4. a. 01-377-2	1. a. 01-192-1&2 b. c.
No. of cables/hose	as required		
Size of cable/hose	2 1/2"	DMP: 7" JP-5: 2 1/2"	2 1/2"
Connection Type			Valved hose connection & funnels
Applicable spec.			
MISC. DATA/REMARKS			

DATA SOURCE: NAVSEC Report No. 6116D3-406-78, August 1981

SHORE UTILITY REQUIREMENTS

SHIP CLASS: CG-47 GUIDED MISSILE CRUISER　　　　sheet 5

	COMPRESSED AIR	TELEPHONE	DATA LINES
QUANTITY REQ. Amps/pressure Demand/Rate		10 lines	
SHIP CONNECTION: Format: a. Location Symbol b. Height above DWL c. Distance inboard		1. a. 01-251-0 b. c.	
No. of cables/hose			
Size of cable/hose			
Connection Type		std. arrestor box	
Applicable spec.			
MISC. DATA/REMARKS			

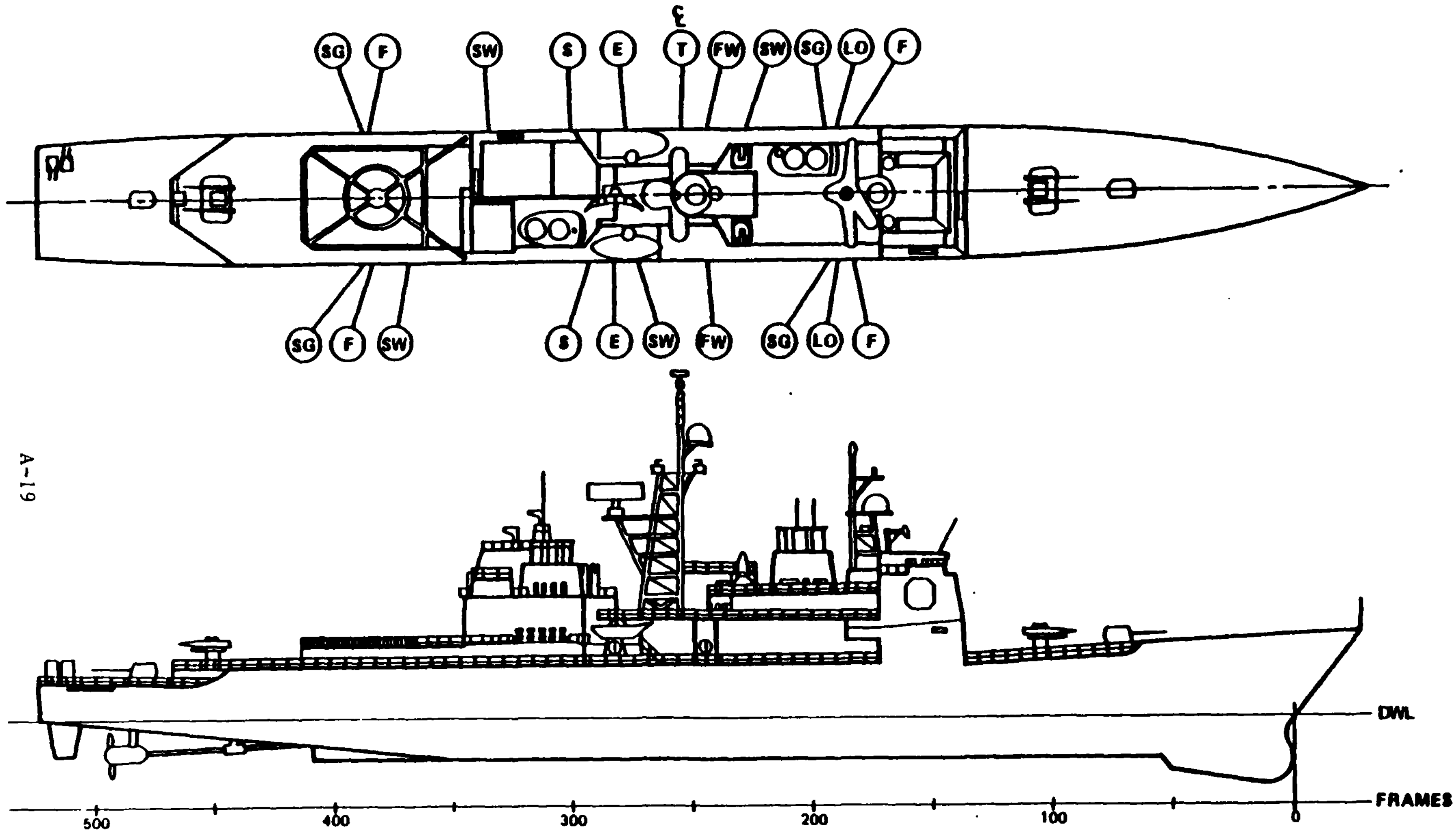
DATA SOURCE: NAVSEC Report No. 6116D3-406-78, August 1981

SHORE UTILITY REQUIREMENTS

SHIP CLASS: CG-47 GUIDED MISSILE CRUISER sheet 6

	SEWAGE	OILY WASTE
QUANTITY REQ. Amps/pressure Demand/Rate	 200 GPM @ 10 psi	
SHIP CONNECTION: Format: a. Location Symbol b. Height above DWL c. Distance inboard	 1. a. 01-190-1&2 b. c. 2. a. 01-380-1&2	
No. of cables/hose		
Size of cable/hose	4" ball valves	
Connection Type	Aeroquip Type 2580	
Applicable spec.		
MISC. DATA/REMARKS		

DATA SOURCE: NAVSEC Report No. 6116D3-406-78, August 1981



CG-47 GUIDED MISSILE CRUISER

PHYSICAL DATA

SHIP CLASS: DD-963 DESTROYER   Sheet 1
(all measurements in feet-inches)

Length Overall	563'
Length Between Perpendiculars (DWL)	529'
Bow Overhang from Forward Perpendicular (frame 0)	33'
Stern Overhang from Aft Perpendicular (frame 529)	1'-9
Breadth, Moulded Maximum	55'
Breadth, Amidships at DWL	54'
Navigational Draft	29'
Lowest Projection below DWL	28'
Highest Projection above DWL	139'-4
Main Deck Height above DWL: Forward	21'-6
Amidships	15'-6
Aft	17'-4
Frame Spacing	1'-0

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Quarterdeck	01 or 1	280 470			
Projections:					
Sonar Dome		3-55	28'		
Propeller		496	25'		
Rudder		512-524	16'		
Bilge Keel		205-352			
Propeller guard		494			6'
Air Masker Bands:		174 220 260 300	All wrap around hull		2 1/16"

PHYSICAL DATA

SHIP CLASS: DD-963 DESTROYER Sheet 2
(all measurements in feet-inches)

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Mooring Chocks:					
(port & starboard except as noted)	1	Bow CL P 4 22 77 132 197 278 290 390 403 498 Stern (P,S, CL)			

DATA SOURCE: NAVSEA S9DDO-GR-SIB-010-060

SHORE UTILITY REQUIREMENTS

SHIP CLASS: DD-963 DESTROYER sheet 3

	ELECTRICAL	STEAM	POTABLE WATER
QUANTITY REQ. Amps/pressure Demand/Rate	 5300 amps Type I, 450 V, 60 Hz	 100 psi	 17,000 GPD
SHIP CONNECTION: Format: a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 03-228-0 b. 47' c. at CL (2800 amps) 2. a. -447-2 b. 14' c. ________. (2800 amps)	1. a. 01-260-1 b. 26' c. 2. a. 01-306-2	1. a. 01-240-1 b. c. 2. a. 01-300-2
No. of cables/hose	14	1	1
Size of cable/hose	T-400	2 1/2" hard rubber	2 1/2"
Connection Type	NSN 5935-00-129-3091 (short pigtail)	2 1/2" connector with 1 1/2" reducer	
Applicable spec.	NAVFAC INST. 11310.44, ship-shore cable		NAVFAC INST. 11300.11, Backflow Preventors
MISC. DATA/REMARKS	See Appendix A, NAVSEASYSCOM message		
DATA SOURCE	NAVSEA 0905-LP-533-3040	S9DDO-GM-SIB-020	

SHORE UTILITY REQUIREMENTS

SHIP CLASS: DD-963 DESTROYER sheet 4

	SALT WATER	FUEL OIL	LUBE OIL
QUANTITY REQ.			
Amps/pressure	150 psi	100 psi	
Demand/Rate	1100 GPM		
SHIP CONNECTION:			
Format:			
a. Location Symbol	Any fire plug on main deck	1. a. 01-184-1	1. a. 01-184-1
b. Height above DWL		b.	b.
c. Distance inboard		c.	c.
		2. a. 01-191-2	2. a. 01-191-2
		3. a. 01-398-1&2	
No. of cables/hose	1 (normal)		1
Size of cable/hose	2 1/2" fire hose		2 1/2"
Connection Type		Quick release probe	Screw-on hose
Applicable spec.		MIL-F-16884, Marine Diesel	
MISC. DATA/REMARKS	Separate seawater cooling system, 75 psi, 1750 GPM		
DATA SOURCE	0905-LP-522-6010		

SHORE UTILITY REQUIREMENTS

SHIP CLASS: DD-963 DESTROYER

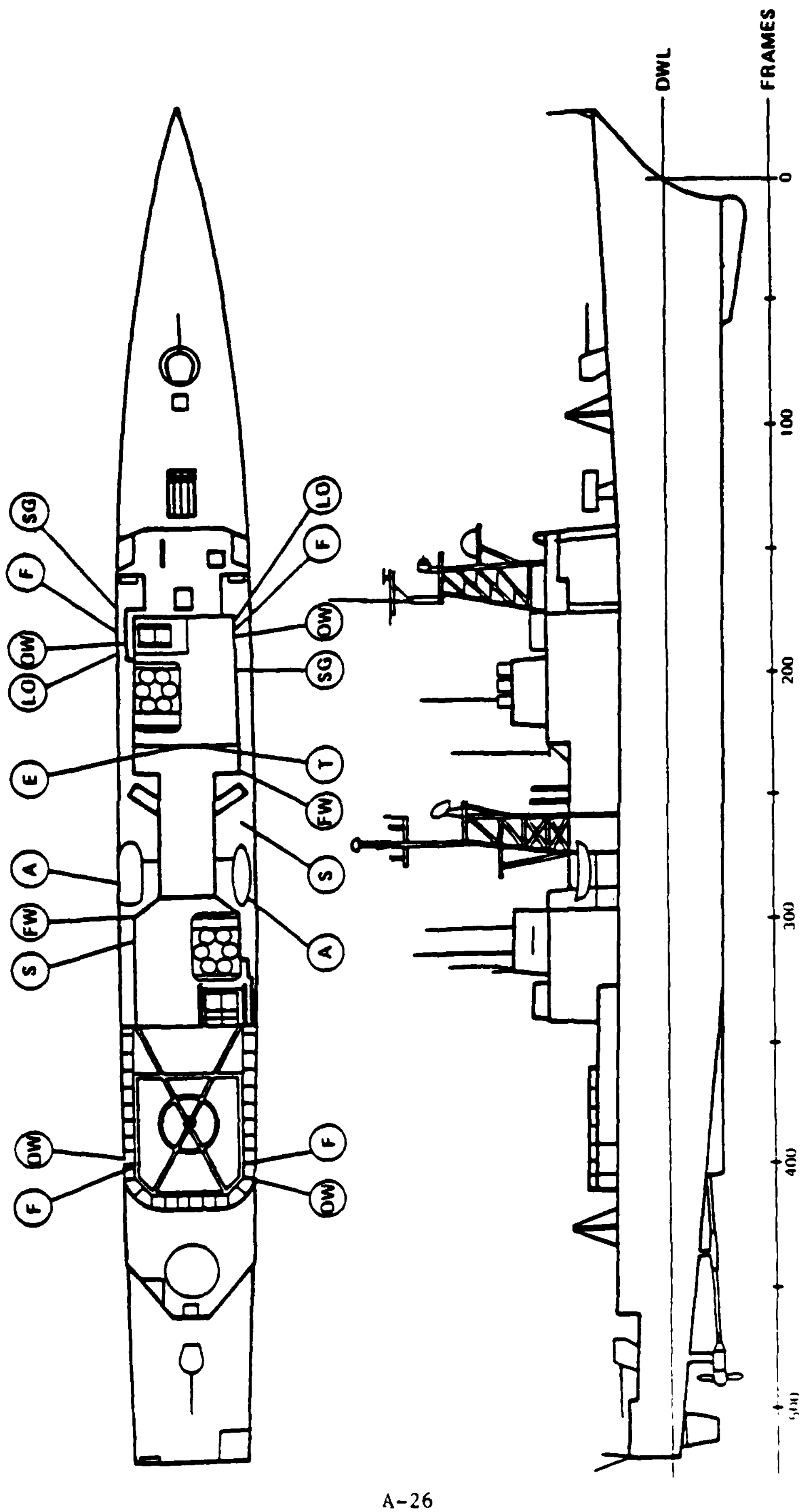
sheet 5

	COMPRESSED AIR	TELEPHONE	DATA LINES
QUANTITY REQ.			
Amps/pressure	100 psi		TBD
Demand/Rate		10 lines	
SHIP CONNECTION:			
Format			
a. Location Symbol	1. a. 1-286-1&2	1. a. 03-228-0	
b. Height above DWL	b.	b.	
c. Distance inboard	c.	c. at CL	
No. of cables/hose	1		
Size of cable/hose	3/4"		
Connection Type	Quick-acting disconnect	Standard 2-cond. cable; screw terminal connection	
Applicable spec.			
MISC. DATA/REMARKS			
DATA SOURCE			

SHORE UTILITY REQUIREMENTS

SHIP CLASS: DD-963 DESTROYER sheet 6

	SEWAGE	OILY WASTE
QUANTITY REQ.		
Amps/pressure		
Demand/Rate	20,600 GPD	5,000 GPD
SHIP CONNECTION:		
Format:		
a. Location Symbol	1. a. 01-197-1&2 b. c.	1. a. 01-184-1 b. c.
b. Height above DWL		
c. Distance inboard	2. a. 01-179-2	2. a. 01-191-2 3. a. 01-398-1&2
No. of cables/hose	1	1
Size of cable/hose	6"	2 1/2"
Connection Type	Aero Quip #1503 with #190016 end adaptor	Standard
Applicable spec.		
MISC. DATA/REMARKS		
DATA SOURCE		



DD-963 DESTROYER

PHYSICAL DATA

SHIP CLASS: DDG 51 (ARLEIGH BURKE) Sheet 1

(all measurements in feet-inches)

Length Overall	504' - 6"	
Length Between Perpendiculars (DWL)	466'	
Bow Overhang from DWL Perpendicular	34'	
Stern Overhang from DWL Perpendicular	4' 6"	
Breadth, Moulded Maximum	66' 5"	
Breadth, Amidships at DWL (Moulded)	59'	
Navigational Draft	30' 8.25"	
Lowest Projection below DWL	30' 8.25" (sonar dome)	
Highest Projection above DWL	150'	
Main Deck Height above DWL: Forward	34' 9"	01 Level
Amidships	21' 10"	01 Level
Aft	16' 6"	Main Deck
Frame Spacing	8', some 7' & 6'	

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	PROJECTION from DWL vertical	HEIGHT above DWL
	NOTED	ON PROFILE	DRAWING		

PHYSICAL DATA

SHIP CLASS: DDG 51 Sheet 2

(all measurements in feet-inches)

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	PROJECTION from DWL vertical	HEIGHT above DWL

DATA SOURCE:

SHORE UTILITY REQUIREMENTS

SHIP CLASS: DDG 51 sheet 1

	ELECTRICAL	STEAM	POTABLE WATER
QUANTITY REQ. Amps/pressure Demand/Rate	3800 delivery 4800 end of service life	NONE	40 psi 2 @ 100 gal/min
SHIP CONNECTION: Location Symbol/ Height above DWL/ Distance inboard	Amidships 21' 10" 33' (Centerline)	NONE	3 CONNECTIONS (1) FR 168 P/S 21' 10" 20' Port & Stbd Connections (2) FR 18 Stbd 34' - 0 2' Inboard (Sonar Dome Fill)
No. of cables/hose Size of cable/hose Connection Type	12 THOF 500* MIL-C-24368		*2 (1 midships) (1 forward) *2-1/2" Hose FED-STD-H28 (Hose Threads)
Applicable spec.	320		SHIP SPEC SECT 532
MISC. DATA/REMARKS	10°F day is the maximum load *Supplied from pier	NONE	*Two 50 foot lengths of 2-1/2 in nps hose carried by ship
DATA SOURCE	NAVSEA	NAVSEA	NAVSEA 56Y3

SHORE UTILITY REQUIREMENTS

SHIP CLASS: DDG 51 sheet 2

	SEA WATER	FUEL OIL	LUBE OIL
QUANTITY REQ. Amps/pressure Demand/Rate	150 psi 2000 gal/min	40 psi F-76:2400 gal/min JP-5:250 gal/min	Gravity Fill 10 gal/min
SHIP CONNECTION: Location Symbol/ Height above DWL/ Distance inboard No. of cables/hose Size of cable/hose Connection Type Applicable spec.	4 CONNECTIONS (1) FR 160 P/S 21' - 10" DK House Side (2) FR 300 P/S 21' - 10" DK House Side 8 2-1/2" Hose 2-1/2-inch NSH with hose thread caps and stay chains SPEC SECT 521	F-76 (1) FR 126 P/S 29' - 4" 7 ft (2) FR 322 P/S 21' - 4" 7 ft 7-inch hose 8-inch flange ANSI B16.5 150 lb rating (3) FR 72 P 25' - 0" 2 ft 6-inch hose 6-inch ASA B16.5 pipe flange JP-5 FR 126 P/S 29' - 4" FR 322 P/S 21' - 4" 7 ft 2-1/2" hose 2-1/2" male thread MIL-F-19488	2 CONNECTIONS (1) FR 1 20' - 4" Centerline (2) FR 300 29' - 4" Centerline Funnel: Dwg. NAVSHIPS 810-1385913 Fill connection: Dwg. NAVSHIPS 810-1385848 Valve: Dwg. NAVSHIPS 803-1385711 SPEC SECT 262
MISC. DATA/REMARKS	Four 2-1/2-inch valve manifolds. Only two manifolds will be used at a time	compensated fuel system	Designed for gravity fill from 55-gallon drums
DATA SOURCE	NAVSEA 56Y3	NAVSEA 56Y3	NAVSEA 56Y3

SHORE UTILITY REQUIREMENTS

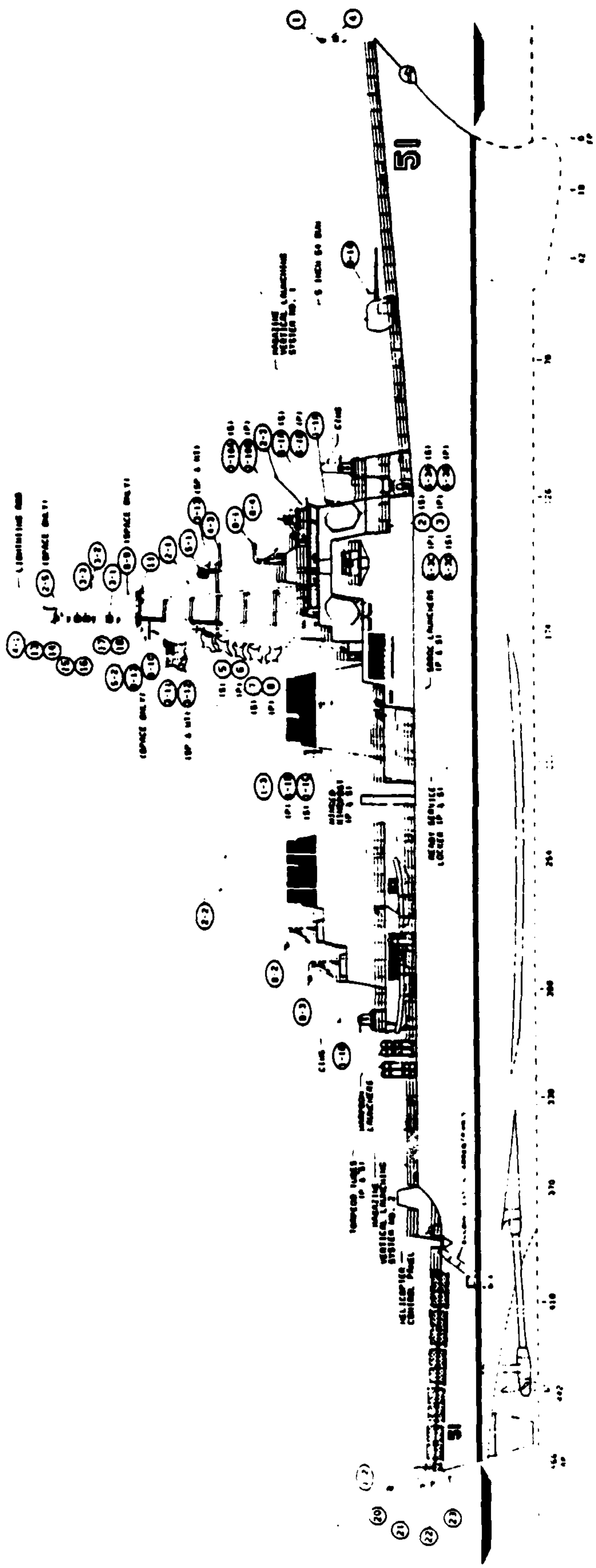
SHIP CLASS: DDG 51 sheet 3

	COMPRESSED AIR	TELEPHONE	DATA LINES
QUANTITY REQ. Amps/pressure Demand/Rate	SHORE AIR RECEIVING 125 peig 300 scfm	NA	NONE
SHIP CONNECTION: Location Symbol/ Height above DWL/ Distance inboard	2 CONNECTIONS (1) FR 112 21' - 10" Centerline (2) FR 240 21' - 10" Centerline	TBD	NONE
No. of cables/hose Size of cable/hose Connection Type	Each deck conn. consists of a globe valve with hose conn. complete with cap & stray chain.	10 telephone cable TA-1003/STC-2V	
Applicable spec.	SPEC SECT 551	802-5774063	
MISC. DATA/REMARKS		AN/STC-2 System IVCS	NONE
DATA SOURCE	NAVSEA 56Y3	NAVSEA 06	NONE

SHORE UTILITY REQUIREMENTS

SHIP CLASS: DDG 51 sheet 4

	SEWAGE	OILY WASTE
QUANTITY REQ. Amps/pressure Demand/Rate	10 psi 100 gpm	10 psi discharge oily waste: 100 gal/min GT waste: 30 gal/min
SHIP CONNECTION: Location Symbol/ Height above DWL/ Distance inboard	*Port/Stbd 21' - 10" 10'	OILY WASTE 2 CONNECTIONS FR 210 P/S 21' - 10" 4' (Approx) GAS TURBINE WASTE 2 CONNECTIONS FR 210 P/S 21' - 10" 4' (Approx)
No. of cables/hose		SUPPLIED FROM SHORE
Size of cable/hose	4" ∅	2-1/2" Hose
Connection Type	Camlock	Camlock NAVSHIPS Dwg #810-2145526
Applicable spec.	593	SPEC SECTIONS 529 & 534
MISC. DATA/REMARKS	*TENTATIVE	
DATA SOURCE	NAVSEA 56	NAVSEA 56Y3



PHYSICAL DATA

SHIP CLASS: FF-1052 FAST FRIGATE Sheet 1
(all measurements in feet-inches)

Length Overall	438'
Length Between Perpendiculars (DWL)	415'
Bow Overhang from Forward Perpendicular (frame 0)	18'
Stern Overhang from Aft Perpendicular (frame 166)	5'
Breadth, Moulded Maximum	46'-10"
Breadth, Amidships at DWL	45'-6"
Navigational Draft	25'
Lowest Projection below DWL	24'-8"
Highest Projection above DWL	120'-9"
Main Deck Height above DWL: Forward	24'
Amidships	
Aft	15'-5
Frame Spacing	2'-6"

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Quarterdeck	01	125 or 152			15'-5"
Projections:					
Sonar Dome		8	24'-8" +		
Propeller		158	22'-3"		
Rudder		160-165	20'-10" +		
Stabilizer fin		75 +	19'-2"		
Propeller guard		157			2'
Bulwark		Bow-24		1'	4' above main deck

PHYSICAL DATA

SHIP CLASS: FF-1052 FAST FRIGATE (all measurements in feet-inches) Sheet 2

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Spray rail		14-45		3'	11'-8" to 14'-6"
Air Masker Bands:		68 87 98	All wrap around hull	0-2"	
Mooring Chocks: (port and starboard except as noted)	1	Bow CL Stern CL 2 12 36 43 75 85 123S 127P 135 156 166			

DATA SOURCE: BUSHIPS Dwg. FF 1090-845-4372194
NAVSEA 0905-474-5010

SHORE UTILITY REQUIREMENTS

SHIP CLASS: FF-1052 FAST FRIGATE sheet 3

	ELECTRICAL	STEAM	POTABLE WATER
QUANTITY REQ.			
Amps/pressure	1200 amps	150 psi	33 psi
Demand/Rate	Type I, 450 V, 60 Hz		
SHIP CONNECTION:			
Format:			
a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 02-84-0 b. 30' c. centerline	1. a. 01-103-1&2 b. c.	1. a. 01-103-1&2 b. c. 6'
No. of cables/hose	3	1	1
Size of cable/hose	T-400A	2 1/2"	2 1/2"
Connection Type	Pigtails NSN-5935-00-129-3091 Lug Conn.		Relief valve 65 psi
Applicable spec.			
MISC. DATA/REMARKS	Dwg DE-1052-302 1949668	Dwg 1052-50-243507	Dwg 1052-506-2435642
DATA SOURCE	0905-474-5030		

SHORE UTILITY REQUIREMENTS

SHIP CLASS: FF-1052 FAST FRIGATE sheet 4

	SALT WATER	FUEL OIL	LUBE OIL
QUANTITY REQ. Amps/pressure Demand/Rate	 125 psi		
SHIP CONNECTION: Format: a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 1-103-1&2 b. c.	1. a. 01-55-1&2 b. c. 2. a. 01-109-1&2 3. a. 01-166-1&2	1. a. 1-100-1 b. c. 2. a. 1-105-2
No. of cables/hose	1		
Size of cable/hose	2 1/2"	2 1/2"	
Connection Type		Std. quick release probe or 6" flange conn.	1 1/2" deck fitting conn.
Applicable spec.			
MISC. DATA/REMARKS			
DATA SOURCE			

SHORE UTILITY REQUIREMENTS

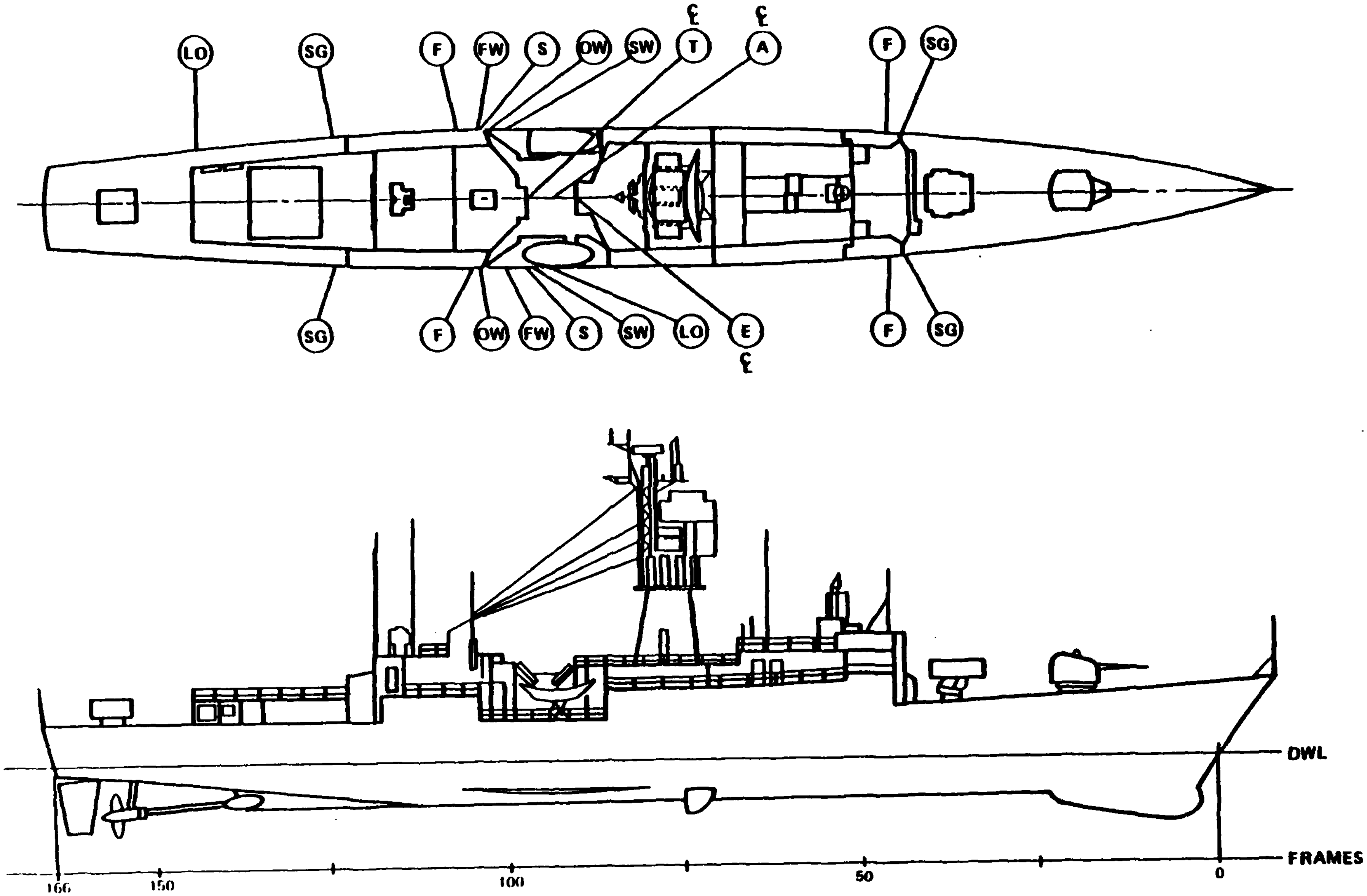
SHIP CLASS: FF-1052 FAST FRIGATE sheet 5

	COMPRESSED AIR	TELEPHONE	DATA LINES
QUANTITY REQ.			
Amps/pressure	100 psi		
Demand/Rate		7 lines	
SHIP CONNECTION:			
Format:			
a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 01-91-0 b. c. centerline	1. a. 01-89-0 b. c. centerline	
No. of cables/hose	1		
Size of cable/hose	3/4"		
Connection Type	Std. quick disconnect	Two conductor plugs.	
Applicable spec.			
MISC. DATA/REMARKS			
DATA SOURCE			

SHORE UTILITY REQUIREMENTS

SHIP CLASS: FF-1052 FAST FRIGATE sheet 6

	SEWAGE	OILY WASTE
QUANTITY REQ.		
Amps/pressure		
Demand/Rate	18,000 GPD	5,000 GPD
SHIP CONNECTION:		
Format:		
a. Location Symbol	1. a. 1-45- 1&2	1. a. 1-103-2
b. Height above DWL	b.	b.
c. Distance inboard	c.	c.
	2. a. 1-124-1&2	2. a. 1-105-1
No. of cables/hose		
Size of cable/hose	6"	1 1/2"
Connection Type	Aero Quip #190016 end fitting adaptor	Female conn.
Applicable spec.		
MISC. DATA/REMARKS		
DATA SOURCE		



FF-1052 FAST FRIGATE

PHYSICAL DATA

SHIP CLASS: FFG-7 GUIDED MISSILE FAST FRIGATE (all measurements in feet-inches) Sheet 1

Length Overall	445'
Length Between Perpendiculars (DWL)	408'
Bow Overhang from Forward Perpendicular (frame 0)	33'
Stern Overhang from Aft Perpendicular (frame 408)	5'
Breadth, Moulded Maximum	47'
Breadth, Amidships at DWL	45'
Navigational Draft	23'-10"+
Lowest Projection below DWL	23'-9"
Highest Projection above DWL	114'-7"
Main Deck Height above DWL: Forward	27'-6"
Amidships	15'-6"
Aft	16'-6"
Frame Spacing	1'-0"

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Quarterdeck	1	189-193			15'-6"
Projections:					
Sonar Dome		40-54	21'-6"		
Propeller		386	23'-10"+		
Rudder		395	20'-7"		
Rodmeter		139	15'-5"		
Stabilizer fin		191	0'-7"		
Bulwark		LL-30			2'-6" avg.
Air Masker Bands:		176 254	All wrap around hull	0-2"	

PHYSICAL DATA

SHIP CLASS: FFG-7 GUIDED MISSILE FAST FRIGATE Sheet 2
(all measurements in feet-inches)

CHARACTERISTIC/ITEM	DECK	FRAME	DEPTH below DWL	HORIZ. PROJECTION from Hull	HEIGHT above DWL
Mooring Chocks: (port and starboard except as noted)	1				
		Bow CL			
		Stern CL			
		P			
		17			
		70			
		84			
		148			
		164			
		236			
		250			
		330			
		352			
		400			
		410			

DATA SOURCE: NAVSEA S9FFG-AM-SIB-010/021/022/030
NAVSURFPAC New Construction General Information Book

SHORE UTILITY REQUIREMENTS

SHIP CLASS: FFG-7 GUIDED MISSILE FAST FRIGATE sheet 3

	ELECTRICAL	STEAM	POTABLE WATER
QUANTITY REQ.			
Amps/pressure	2800 amps	100 psi	50 psi
Demand/Rate	Type 1, 450V, 60 Hz		10,750 GPD
SHIP CONNECTION:			
Format:			
a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 02-219-0 b. 35' c. centerline	1. a. 02-293-2 b. 35' c. 2. a. 02-285-1	1. a. 02-285-1&2 b. 35' c.
No. of cables/hose	7	1	1
Size of cable/hose	T-400	2"	
Connection Type	MIL-C-24368, Receptacle		1 1/2" hose valves
Applicable spec.			
MISC. DATA/REMARKS		Relief valve at 125 psi	
DATA SOURCE			

SHORE UTILITY REQUIREMENTS

SHIP CLASS: FFG-7 GUIDED MISSILE FAST FRIGATE sheet 4

	SALT WATER	FUEL OIL	LUBE OIL
QUANTITY REQ.			
Amps/pressure	150 psi	100 psi	
Demand/Rate			
SHIP CONNECTION:		F-76:	
a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 1-254-1&2 b. 18' c.	1. a. 02-133-1&2 b. 35' c. 2. a. 02-284-1&2 b. 35' c. JP-5: 1. a. 02-303-1&2	1. a. 02-289-1&2 b. 35' c.
No. of cables/hose	1		
Size of cable/hose	2 1/2"	F-76: 7" JP-5: 4"	
Connection Type			Valved hose adapter or funnel.
Applicable spec.			
MISC. DATA/REMARKS			
DATA SOURCE			

SHORE UTILITY REQUIREMENTS

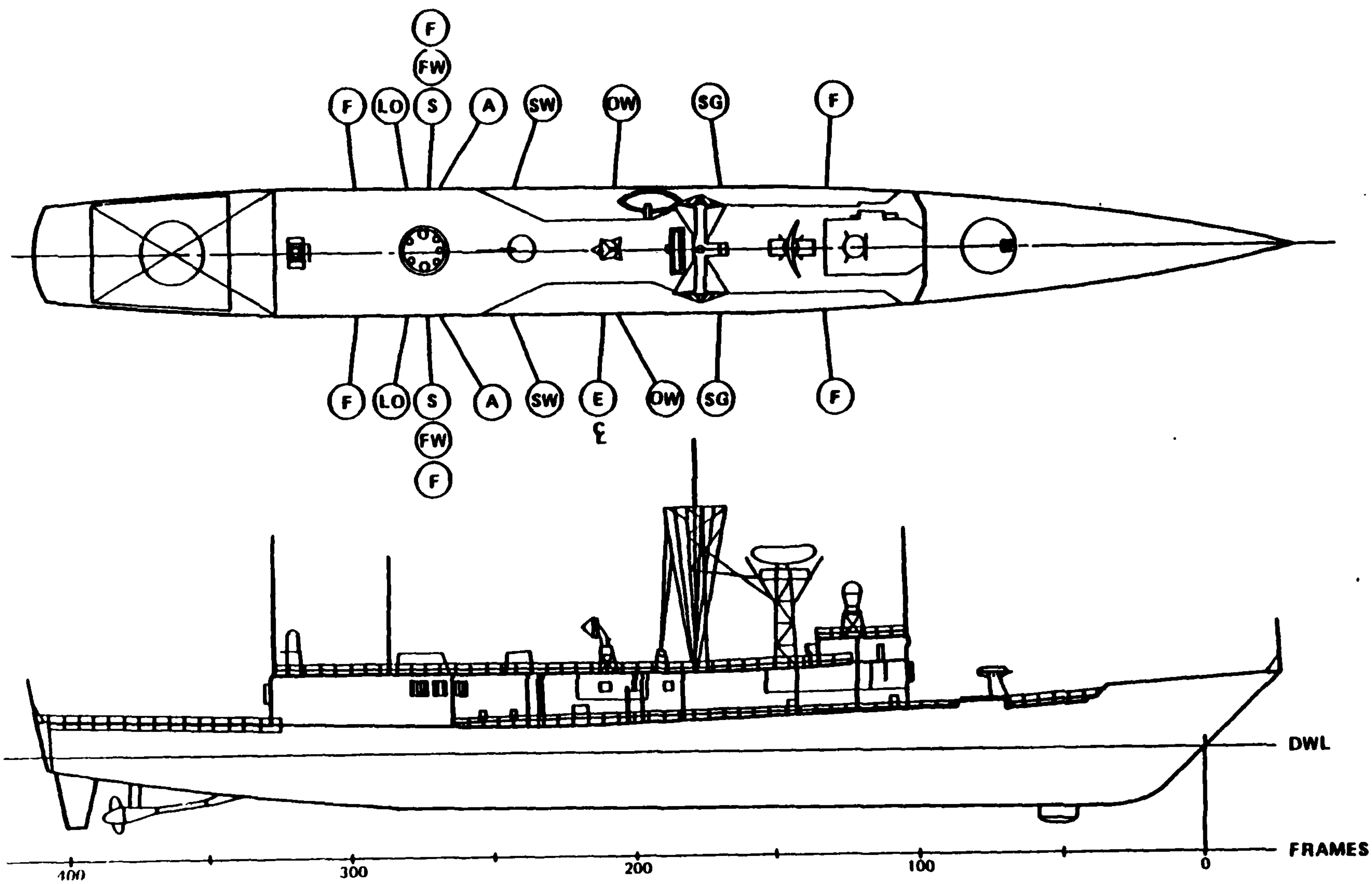
SHIP CLASS: FFG-7 GUIDED MISSILE FAST FRIGATE sheet 5

	COMPRESSED AIR	TELEPHONE	DATA LINES
QUANTITY REQ. Amps/pressure Demand/Rate	125 psi	7 lines	TBD
SHIP CONNECTION: a. Location Symbol b. Height above DWL c. Distance inboard No. of cables/hose Size of cable/hose Connection Type Applicable spec.	1. a. 02-221-1 b. 35' c. 2. a. 02-211-2 3. a. 02-282-1&2 3/4" connection		
MISC. DATA/REMARKS			
DATA SOURCE			

SHORE UTILITY REQUIREMENTS

SHIP CLASS: FFG-7 GUIDED MISSILE FAST FRIGATE sheet 6

	SEWAGE	OILY WASTE
QUANTITY REQ. Amps/pressure Demand/Rate	 12,900 GPD	 5,000 GPD
SHIP CONNECTION: a. Location Symbol b. Height above DWL c. Distance inboard	1. a. 1-170-1 b. 18' c. 2. a. 1-173-2	1. a. 1-215- 1&2 b. c.
No. of cables/hose	1	1
Size of cable/hose	4"	2 1/2"
Connection Type		
Applicable spec.		
MISC. DATA/REMARKS	NAVSHIP Dwg 810-4444650	
DATA SOURCE	S9FFG-AM-SIB-010	



FFG-7 GUIDED MISSILE FAST FRIGATE

ABBREVIATIONS

A	-	Compressed Air
AMPS	-	Ampere
CL	-	Centerline
DWL	-	Design Waterline
E	-	Electrical
F	-	Fuel Oil
F-76	-	Fuel, Naval Distillate
FR	-	Frame
FW	-	Potable Water
FWD	-	Forward
GPD	-	Gallons Per Day
GPM	-	Gallons Per Minute
H/P	-	High Pressure Air
JP-5	-	Jet Aircraft Fuel
LO	-	Lube Oil
L/P	-	Low Pressure Air
MIL	-	Military Standard
N/A	-	Not Applicable
N/S	-	National Stock Number
OW	-	Oily Waste
P&S	-	Port and Starboard
psi	-	Pounds Per Square Inch
S	-	Steam
SG	-	Sewage
SW	-	Salt Water
T	-	Telephone
TBD	-	To Be Determined

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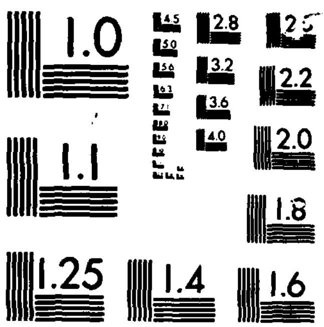
UNCLASSIFIED F/G 13/10 NL



MICROCOP' CHART

DEFINITIONS

Air Masker Bands	-	Protruding air conduits running vertically around the ship hull to mask noise emission.
Brow	-	Gangway for personnel ingress/egress.
Bulwark	-	A solid wall along main deck to serve as a spray shield.
Design Waterline (DWL)	-	Waterline at which the ship is designed to float.
Fantail	-	Main deck at rear part of ship.
Forecastle	-	Main deck at forward part of ship.
Forward (first) Perpendicular	-	Where the stern contour intersects the design waterline at the bow.
Navigational Draft	-	Maximum draft required for the ship.
Quarterdeck	-	Part of main or other deck reserved for OOD in port, ships official business, and primary ingress point.
Rodmeter	-	Metal rod projecting below keel to measure speed.

REFERENCES

1. Proceedings of a Workshop Held at NCEL, 24-26 Feb 1981.

2. Concept Study for Berthing Pier, Naval Station, Charleston, SC; Gee & Jenson Engineers, Architects, Planners, Inc. Sept 1982.

3. Conceptual Design of Floating Navy Pier, T. Y. Lin International, April 1982.

4. Engineering Services for Navy Pier Facilities and Related Tasks, Brown and Root Development, Inc., February 1983.

ADDITIONAL REFERENCE SOURCES

- CEL Port Guide for DD-963 class.

- CEL port Guide for FF-1052 class.

- The Ships, and Aircraft of the U.S. Fleet, 12th Edition, Norman Polmar, Naval Institute Press.

- New Construction General Information Book, COMNAVSURFPAC, December 1980.

- NAVSEA PUB S0300-AF-GIP-010, Plans and Elevations Surface Ships.

- Jane's Fighting Ships, 1979-80, Franklin Watts, Inc.

- The following are NAVSEA publications used as sources for individual classes:

  AD-37 Class

  Ship's Information Book SIB-AD-37

  AD-41 Class

  NAVSEA 0905-LP-524-8020/8040/8090
  NAVSEA 0905-LP-524-9010/9020/9030/9090
  NAVSHIPS DWG 810-4444650

  CG-47 Class

  NAVSEA Report No.
  6116D3-406-78 (revised 8/81)

DD-963 Class

NAVSEA 0905-LP-522-6010, POG
NAVSEA 0905-LP-533-3040
S9DDO-GR-SIB-010, Vol 1
S9DDO-GR-SIB-020, Vol 2
S9DDO-GR-SIB-030, Vol 2
S9DDO-GR-SIB-040, Vol 2
S9DDO-GR-SIB-050, Vol 3
S9DDO-GR-SIB-060, Vol 3

FFG-7 Class

S9FFG-AM-POG-010, POG
S9FFG-AM-SIB-010 Vol 1
S9FFG-AM-SIB-021 Vol 2
S9FFG-AM-SIB-022 Vol 2
S9FFG-AM-SIB-030 Vol 3

FF-1052 Class

NAVSEA 0905-474-5010/5030
S9FFO-89-POG-010, POG
S905-077-6010, Vol 1
S905-077-6011, Vol 1
S905-077-6020, Vol 2
S905-077-6030, Vol 3
BUSHIPS Drawing FF1090 845 4 372194 Rev D

APPENDIX B

PRELIMINARY PROPOSED PROCUREMENT SPECIFICATION

RESILIENT FOAM-FILLED FENDER SYSTEMS

USER INFORMATION

1.0 INTRODUCTION

NCEL has followed the development and monitored the performance of foam fenders since the mid 1970's, first for amphibious operations and more recently for harbor use. The specifications included herein are based on a review of Navy performance experience, requirements, and recent procurement problems and discussions with leading fender manufacturers The end product represents an iterative effort during FY84 to define the minimum Government requirement, foster sufficient and fair competition among vendors, and protect against the acquisition of an inferior product.

The specifications should be considered preliminary, subject to revision in the future based on results from NCEL's ongoing evaluation efforts and user inputs. More significatnly, a MILSPEC is currently being drafted which will be distributed to users and manufacturers for comment prior to its anticipated finalization in late FY85. The MILSPEC will of course ultimately supersede the guide specification included herein.

2.0 SELECTION

There are two basic fender types which may be procured, resulting in a separate specification for each. One has a chain and tire net for rigging the fender while the other relies on an internal end fitting for this function. They are commonly referred to as "net" and "netless" respectively.

Both have performed acceptably in Navy applications and have been well received by the fleet. While early concerns were raised as to possible skin puncture and tear problems due to the greater hull protrusions and appendages or Navy ships vis-a-vis commercial vessels, such problems have not materialized. It was also assumed that the netless fender would be more susceptible to such problems, but again experience has shown otherwise.

The principal operational difference between the two fender types is that the "netless" causes less hull marking than the "net" and the marks are considered easier to remove by ship crews. The "netless" can also be anticipated to have lower maintenance costs as the chain and tire net deteriorates with time. As a result of these advantages the netless would clearly be the preferred choice. if it didn't cost more than the net fender. While in NCEL's opinion the advantages outweigh the incremental additional cost, each activity will have to consider this in light of its own budget limitations and fender preferences.

3.0 USE

When using foam fenders, certain precautions should be observed. While the skins are generally quite resistant to the typical environment at Navy ports (e.g. paint, oil, salt water), they are vulnerable to chemical and heat attack, particularly in combination and over an extended period of time. Contact with an engine exhaust portal such as on a pusher boat should be minimized. Also an attempt should be made to locate the ship/fender interface so that steam is not impinging directly on the fender.

In attaching the fender to the pier the chain length should be minimized by mounting it at the mid-tidal point. This will minimize fender off-set from the bearing wall. Where feasible a bearing wall longer than the fender is also desirable. Redundancy in the fender tie down is recommended through, for example, a secondary wire rope. Sailors have been known to detach shackles from a fender resulting in the fender floating away from the berth. A few tack welds of other method of discouraging tampering is also worth considering.

As with other fender systems damage will eventually occur. Kits are available from vendors to repair small skin punctures or tears. More extensive damage can usually be repaired by the manufacturers, although the repair cost should be weighed against the cost of a new fender. The chain and tire net can be expected to require occasional maintenance to: (a) tighten the chain rigging to prevent its slipping out of position on the fender shell, (b) replace corroded chain and shackles, (c) replace tires which have been torn/loosened from the chain rigging.

4.0 PROCUREMENT

Experience to date on Navy procurements has shown an almost two-fold variation in purchase price depending largely on the degree of competition. Accordingly, users are encouraged to avoid sole source or otherwise limited procurements. The specifications presuppose a large enough order to justify first article testing. For small orders (e.g. 3 or 4 fenders) consideration might be given to waving the 1st article testing requirements.

While the 6 X 12 foot size fender specified herein was selected as the size most suitable for the majority of Navy applications, the specifications can be modified to address other sizes. In the interest of Navy standardization it is suggested that increases of both diameter and length be made in two foot increments. The MILSPEC mentioned earlier will likely address multiple fender fender sizes.

3 August 1984

PURCHASE DESCRIPTION FOR
6x12-FOOT NETLESS MARINE FENDER

1. SCOPE

1.1 Scope - (a) This specification covers a high energy absorption elastomeric marine fender system to be used for protection of ships, harbor craft, wharves, and piers from damage between the interface of vessel to vessel or vessel to pier.

2. APPLICABLE DOCUMENTS

2.1 Government Documents

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODSIS) specified in the solicitation, form a part of the purchase description to the extent specified herein.

SPECIFICATION

Federal

RR-C-271 - Chains and Attachments, Welded and Weldless

Military

MIL-I-45208 - Inspection System Requirements

MIL-S-24214 (Ships) - Shackles, Steel, General Purpose Regular and High Strength

MIL-P-40619 - Water Absorption (ASTM D-1667)

STANDARDS

Federal

FED-STD-595 - Color

(Copies of the above specifications may be obtained from the U.S. Naval Publications and Forms Center or as directed by the contracting officer.)

2.2 Other Publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DOD adopted shall be the issue listed in the current DODISS and the supplement thereto, if applicable. The issues of

other documents, unless otherwise indicated, shall be the issue in effect on the date of the Invitation for Bid or Request for Proposal of which this Purchase Description forms a part thereto.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM):

D-1564 - Flexible Cellular Materials Sponge or Expanded Rubber, Standard Method of Testing

D-2240-81 - Rubber Property Durometer Hardness, Test for

D-1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (closed cell vinyl)

D-1630-61 - Rubber Property Abrasion Resistance, Test for (NBS Abrader)

D-1056 - Flexible Cellular Material Sponge or Expanded Rubber, Specification for

D-624 - Rubber Property Tear Resistance, Test for

D-412-80 - Rubber Properties in Tension, Test Methods for

D-3574 - Flexible Cellular Materials - Slab, Bonded, and Molder Urethane Foams

D-395 - Rubber Property in Compression, Test for

D-470-81 - Thermosetting Insulated and Jacketed Wire and Cable

D-1052-55 - Measuring Rubber Deterioration, Method for (Cut Growth Using Ross Flexing Apparatus)

D-750 - Rubber Deterioration in Carbon Arc or Weatherometer, Recommended Practice for: (Atlas Weatherometer Model XW with Filters and Curved Racks)

A-123-78 - Zinc (Hot Galvanized) Coatings on Products fabricated from rolled, pressed, and forged shapes, bars, and strips

A-153-78 - Zinc Coating (Hot Dip) on Iron and Steel Hardware

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

2.3 Order of precedence. In the event of a conflict between the text of this purchase description and the references cited herein, the text of this purchase description shall take precedence.

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 First article. The contractor shall furnish one complete item of each of the items comprising the fendering system as a sample for first article inspection and approval (see 4.2.1).

3.2 Drawings. The contractor is responsible for preparing his own shop drawings. Where tolerances prescribed may cumulatively result in incorrect fits, the contractor shall provide tolerances within those prescribed herein to insure correct fit, assembly, and operations of the items. No deviation from the prescribed dimensions or tolerances is permissible without prior approval of the contracting officer.

3.3 Materials. Materials used shall be free from defects which would adversely affect the performance or maintainability of individual components or of the overall assembly. Materials specified herein shall be of the same quality used for the intended purpose in commercial practice. Unless otherwise specified herein, all equipment, material, and articles incorporated in the work covered by this purchase description are to be new and fabricated using materials produced from recovered materials to the maximum extent possible without jeopardizing the intended use. The "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products are allowed under this purchase description unless otherwise specified.

3.3.1 Closed cell foam. Closed cell foam used in the fender cushion shall be completely filled with a closed cell crosslinked polyethylene plastic foam of the characteristics listed in Table 1.

Table 1. Closed Cell Foam

Density (ASTM D1667)	1.5 - 3.5 lb/ft^3
Tensile Strength (ASTM D1564 or D412)	50 lb/in.^{2} (psi), minimum
Elongation (ultimate) (ASTM D1564 or D412)	200%, minimum % to break
Continuous Service Temperature	-75°F to +175°F, minimum range
Water Absorption (after 24-hr immersion) (ASTM 1667)	0.07 lb/ft^2 of cut surface, maximum
Tear Resistance (ASTM D624)	7 lb/in., minimum
25% Compressive Resistance (ASTM D1667 or D1056)	4 psi minimum
25% Compressive Set (ASTM D395 or D1667)	13%, maximum

3.3.2 Elastomer (urethane) shell. The elastomer shell encasing the fender cushion shall be 1.25 inch minimum thickness and shall be a polyether urethane elastomer (PTMEG) of the charasteristics listed in Table 2 and formulated to be ultraviolet inhibited.

Table 2. Urethane Elastomer Component of Shell

(a)	Shore "A" Durometer Hardness (ASTM D2240-75)	85-92
(b)	Tensile Strength (ASTM D412-80, Method A, Section 11-14)	2,000 psi minimum
(c)	Elongation (ultimate) (ASTM D412-80, Method A, Section 11-14)	500% minimum
(d)	Tear Strength (ASTM D470-81, Section 7.6)	100 lb/in.
(e)	Flex Cut Growth (Ross, flexes to 5x cut growth, ASTM D1052-55)	10,000 flexes minimum
(f)	Abrasion Resistance, NBS Abrader (ASTM D1630-61)	125 minimum
(g)	Weatherometer Aging - 500 hours (ASTM D750-68)	Minimum 60% retention of original values of specification items (a) through (d) above

3.4 Interchangeability. All fenders of the same classification furnished with similar options under a specific contract shall be identical to the extent necessary to insure interchangeability of component parts, assemblies, accessories, and spare parts.

3.5 Design. The components of the fender system shall be as described herein.

3.5.1 General configuration. The fender shall have a cylindrical mid-body with conical or curved ends terminating in an end fitting on each end of the cylinders centerline. The mid-body shall have a minimum

diameter of 6.0 feet ±1.5 inches and a length of 7.5 feet ±6 inches. The fender length from eye to eye of the end fittings shall be 12.25 feet ±6 inches. The fender shall be manufactured with a fabricated core of closed cell foam (see 3.3.1), encased in an elastomer-shell (3.3.2). The fender shall have no exterior net or solid (non-compressible) interior longitudinal strength member connecting the fender end fittings.

Table 3. Fender Performance Parameters

Size	6-ft diameter x 12-ft long
Energy Absorption at 60% compression	210,000 ft-lb minimum
Reaction Force at the 210,000 ft-lb energy absorption point	160,000 lb maximum

3.5.2 Fender Skin Construction. The skin of the fender shall be constructed of polyurethane elastomer (see Table 2) to form a fender shell having a minimum thickness of 1.25 inches. The contractor shall certify that any seam of the fender is produced in such a manner as to assure a continuous homogeneous skin, with joint strength equal to that of the rest of the fender shell. Up to 12 filament reinforcing wraps of nylon tire cord may be used at the contractor's option. If filament wraps are used they shall be evenly distributed and the elastomer shall be applied in a continuous manner to assure adhesion between the various layers.

3.5.3 End Fittings. The end fittings shall be connected by a chain and shall terminate in a clevis fitting sized for a 1-inch minimum shackle and shall swivel to allow the end fitting to rotate freely on the axis of the fender. The end fittings shall be designed to transmit the ultimate load of the shackle to the fender. The end fittings shall be cast ductile iron or fabricated A-36 steel and hot-dipped galvanized in accordance with ASTM A-153 or ASTM A-123.

3.5.4 Color. The fender skin color shall be black. Galvanized metal hardware shall be unpainted.

3.5.5 Repairability. The fender casing shall be repairable in the event of tears or punctures in the urethane shell. The repaired area shall have not less than 90% of the properties as specified in 3.3.2. Required repair materials shall be readily available from the fender manufacturer.

3.6 Workmanship.

3.6.1 Urethane Shell. The urethane shell of the fender shall be free from cracks, burrs, warpage, checks, chipped, or blistered surfaces and shall have a smooth surface.

3.6.2 Steel Fabrication. The steel used in fabrication shall be free from kinks, sharp bends, and other conditions which would be deleterious to the finished product. Manufacturing processes shall not

reduce the strength of the steel to a value less than intended by the design. Manufacturing processes shall be done neatly and accurately. All bends shall be made by controlled means to insure uniformity of size and shape.

3.6.3 Foam Core. The foam core shall be homogeneous and of one piece fabricated construction and shall not be in chip or granular form, neither lose packed nor bound with a discontinuous filler material.

3.6.4 Welding. Welding procedures shall be in accordance with a nationally recognized welding code. The surface of parts to be welded shall be free from rust, scale, paint, grease, or other foreign matter. Welds shall be of sufficient size and shape to develop the full strength of the parts connected by the welds. Welds shall transmit stress without permanent deformation or failure when the parts connected by the weld are subjected to proof and service loadings.

3.7 Inspection System. The contractor shall establish an inspection system in accordance with MIL-I-45208.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. Unless otherwise specified herein, the contractor is responsible for the performance and cost of all inspection and test requirements. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities

suitable for the performance of the inspection and test requirements specified unless disapproved by the Government. The First Article test report shall be signed by an authorized Government representative as evidence that the examination and tests were witnessed by the representative and that the results were reported therein. The Government reserves the right to perform or witness any of the inspections or tests set forth in the specification where such inspections or tests are deemed necessary to assure that the fenders conform to prescribed requirements. Upon completion of all inspection and test requirements, the contractor will certify in writing, with notorized copies of all results, to the procurement office that all inspections and tests were performed as required and that the fenders successfully passed all inspections and tests as specified herein.

4.2 Classification of Inspection. Inspection shall be classified as follows:

(a) First article inspection (see 3.1 and 4.2.1)

(b) Quality conformance inspection (see 4.2.2)

4.2.1 First Article Inspection. First article inspection shall be performed on a complete contract item. This inspection shall include the examination of 4.3 and tests of 4.4.

4.2.2 Quality Conformance Inspection. Quality conformance inspection shall be performed on each item in accordance with the examination of 4.3 and 4.4.4.

4.3 Examination. Each contract item shall be examined for compliance with the requirements specified in Section 3 of this purchase description. This element of inspection shall encompass all visual examinations and dimensional measurements. Records maintained in accordance with 3.7 shall be inspected by the Government to verify that the materials used in construction of all contract items conform to the requirements stated herein. Any redesign or modification of the contractor's product to comply with specified requirements, or any necessary redesign or modification following failure to meet specified requirements shall receive particular attention for adequacy and suitability. Noncompliance with any specified requirements or presence of one or more defects preventing or lessening maximum efficiency shall constitute cause for rejection.

4.4 Tests. The First Article shall be tested to determine compliance with this purchase description. Tests shall be conducted as specified in 4.4.1 through 4.4.3.

4.4.1 Fender. The following tests apply to an assembled fender.

4.4.2 Energy Absorption Capacity and Reaction Force. The First Article fender shall be compressed between two parallel flat plate surfaces to 40% of its original diameter (this shall be referred to as the 60% compression point) by an evenly distributed load, perpendicular to its longitudinal axis at a rate not less than 2.4 inches per minute. The load and corresponding deflection shall be recorded at one-inch increments and plotted on a graph of load versus deflection. The load

deflection curve shall then be integrated to generate an energy-deflection curve for the fender. At the 60% compression point (deflection of 43.2 inches) on the energy-deflection curve, the energy absorption shall be not less than 210,000 ft/lb. Upon release of the load, the fender shall show no sign of permanent distortion, rips, tears, delaminations, or other defects. Thirty minutes after release of the compression load visible permanent deformation or elongation of the fender or compression set exceeding 4% (relative to the start of the test) shall constitute failure of the test. The reaction force shall be that force required to deflect the fender to its rated energy absorption of not less than 210,000 ft/lb. This force shall be taken from the force-deflection curve and shall not exceed 160,000 pounds.

4.4.3 Strength Tests. The fender shall be compressed between two parallel flat plate surfaces to the working compression limit (60%). The fender shall be held at the working compression during the strength tests of 4.4.3.1 and 4.4.3.2 (Figure 1). The fender shall be restrained from sliding from between the compression plates by rigging a stop plate perpendicular to the direction of pull (Figure 1). (Extrusion of the fender through the slot shall not constitute failre of the test. However, adequate safety precautions should be taken in the event extrusion of the fenders occurs.)

4.4.3.1 Longitudinal Pull Test. The stop plate and its opening shall be centered vertically and horizontally about the midpoint of the longitudinal centerline of the compressed fender. The opening in

the stop plate shall have a width that is not less than 2 inches wider than the maximum width of the fender end fitting or elastomer collar. The opening shall have a minimum height that is 4 inches longer that the thickness of the compressed fender. The end fitting opposite to the stop plate shall be free during the test. The end fitting adjacent to the stop plate shall be subject to a tensile load applied in line with the longitudinal axis of the compressed fender in 10,000 lb increments up to a load equal to 50,000 lb. Each incremental load shall be held for 1 minute and the final load held for 5 minutes. The loads shall then be released and the fender allowed to return to its original shape. There shall be no tears, delaminations or permanent deformation which would affect the mechanical integrity of the fender. The end fitting shall show no sign of permanent deformation or separation from the fender.

4.4.3.2 Transverse Pull Test. A stop plate shall be centered between the two ends of the compressed fender and the plate shall be such that it will not interfere with the end fittings or the elastomer collars during the test. Both end fittings shall be simultaneously subjected to a tensile load applied perpendicular to the longitudinal axis of the fender and in a horizontal plane parallel to the platens (Figure 1). The load shall be applied simultaneously to each end fitting in 10,000 lb increments up to a load equal to 50,000 lb. Each incremental load shall be held for 2 minutes and the final load held for 5 minutes. The loads shall then be released and the fender allowed to return to its original shape. There shall be no tears, delaminations or

permanent deformation which would affect the mechanical integrity of the fender. The end fittings shall show no sign of permanent deformation or separation from the fender.

4.4.4 Urethane Elastomer Retains. Test Coupons of the Urethane Elastomer used to manufacture each fender shall be identified and retained by the contractor for a period of not less than 5 years from the date of fender manufacture. A coupon from every third fender of the lot shall be submitted to an independent laboratory for physical testing in accordance with Paragraph 3.3.2 (a)-(d). An example of coupon selection is fender 1, 4, 7, 10, 13 etc. The certified test results of these tests are to be submitted to the Cognizant Contract Quality Control Representative for approval. The government reserves the right to request any of the remaining specimens within the 5 year period and perform any or all of the tests of 3.3.2 at government expense. The test coupons shall be 36 sq in. minimum by .09 ± .03 inches thick.

4.4.4.1 Collection fixture.

(a) If fender skin is cast in a mold, the fixture shall be a mold of the above minimum dimension.

(b) If fender skin is built up by spraying, the fixture shall be a flat plate of 36 sq in. area or greater.

4.4.4.2 Fixture preparation. The appropriate fixture with release agent applied is to be at the same temperature as the fender skin when formed.

4.4.4.3 Coupon collection.

(a) If the fender skin is cast in a mold, the coupon mold is to be filled with liquid urethane collected from the pour stream at the mold fill point.

(b) If the fender skin is built-up by spraying, the collection fixture is to be passed through the spray stream so that one layer, equivalent to one layer of urethane on the fender shell, is applied. This procedure is to be repeated until the specified coupon thickness is achieved. The time between coats is to be the same as the time between layers applied to the fender shell.

4.4.4.4 Coupon curing. The coupon is to be cured under the same conditions as the fender shell.

4.4.4.5 Frequency of Collection. One or more coupons are required for each fender as specified below.

(a) If cast in a mold, one coupon is required for each component cast, i.e., ends, cylinder, joints, etc.

(b) If sprayed, a minimum of one coupon, representative of the skin cross section, is required.

10 August 1984

PURCHASE DESCRIPTION FOR
6x12-FOOT CHAIN AND TIRE NET MARINE FENDER

1. SCOPE

1.1 Scope - (a) This specification covers a high energy absorption elastomeric marine fender system to be used for protection of ships, harbor craft, wharves, and piers from damage between the interface of vessel to vessel or vessel to pier.

2. APPLICABLE DOCUMENTS

2.1 Government Documents

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODSIS) specified in the solicitation, form a part of the purchase description to the extent specified herein.

SPECIFICATION

Federal

RR-C-271 - Chains and Attachments, Welded and Weldless

Military

MIL-I-45208 - Inspection System Requirements

MIL-S-24214 (Ships) - Shackles, Steel, General Purpose Regular and High Strength

MIL-P-40619 - Water Absorption (ASTM D-1667)

STANDARDS

Federal

FED-STD-595 - Color

(Copies of the above specifications may be obtained from the U.S. Naval Publications and Forms Center or as directed by the contracting officer.)

2.2 Other Publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DOD adopted shall be the issue listed in the current DODISS and the supplement thereto, if applicable. The issues of

other documents, unless otherwise indicated, shall be the issue in effect on the date of the Invitation for Bid or Request for Proposal of which this Purchase Description forms a part thereto.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM):

D-1564 - Flexible Cellular Materials Sponge or Expanded Rubber, Standard Method of Testing

D-2240-81 - Rubber Property Durometer Hardness, Test for

D-1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (closed cell vinyl)

D-1630-61 - Rubber Property Abrasion Resistance, Test for (NBS Abrader)

D-1056 - Flexible Cellular Material Sponge or Expanded Rubber, Specification for

D-624 - Rubber Property Tear Resistance, Test for

D-412-80 - Rubber Properties in Tension, Test Methods for

D-3574 - Flexible Cellular Materials - Slab, Bonded, and Molder Urethane Foams

D-395 - Rubber Property in Compression, Test for

D-470-81 - Thermosetting Insulated and Jacketed Wire and Cable

D-1052-55 - Measuring Rubber Deterioration, Method for (Cut Growth Using Ross Flexing Apparatus)

D-750 - Rubber Deterioration in Carbon Arc or Weatherometer, Recommended Practice for: (Atlas Weatherometer Model XW with Filters and Curved Racks)

A-123-78 - Zinc (Hot Galvanized) Coatings on Products fabricated from rolled, pressed, and forged shapes, bars, and strips

A-153-78 - Zinc Coating (Hot Dip) on Iron and Steel Hardware

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

2.3 Order of precedence. In the event of a conflict between the text of this purchase description and the references cited herein, the text of this purchase description shall take precedence.

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 First article. The contractor shall furnish one complete item of each of the items comprising the fendering system as a sample for first article inspection and approval (see 4.2.1).

3.2 Drawings. The contractor is responsible for preparing his own shop drawings. Where tolerances prescribed may cumulatively result in incorrect fits, the contractor shall provide tolerances within those prescribed herein to insure correct fit, assembly, and operations of the items. No deviation from the prescribed dimensions or tolerances is permissible without prior approval of the contracting officer.

3.3 Materials. Materials used shall be free from defects which would adversely affect the performance or maintainability of individual components or of the overall assembly. Materials specified herein shall be of the same quality used for the intended purpose in commercial practice. Unless otherwise specified herein, all equipment, material, and articles incorporated in the work covered by this purchase description are to be new and fabricated using materials produced from recovered materials to the maximum extent possible without jeopardizing the intended use. The "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products are allowed under this purchase description unless otherwise specified.

3.3.1 Closed cell foam. Closed cell foam used in the fender cushion shall be completely filled with a closed cell crosslinked polyethylene plastic foam of the characteristics listed in Table 1.

Table 1. Closed Cell Foam

Density (ASTM D1667)	1.5 - 3.5 lb/ft^3
Tensile Strength (ASTM D1564 or D412)	50 lb/in.^{2} (psi), minimum
Elongation (ultimate) (ASTM D1564 or D412)	200%, minimum % to break
Continuous Service Temperature	-75°F to +175°F, minimum range
Water Absorption (after 24-hr immersion) (ASTM 1667)	0.07 lb/ft^2 of cut surface, maximum
Tear Resistance (ASTM D624)	7 lb/in., minimum
25% Compressive Resistance (ASTM D1667 or D1056)	4 psi minimum
25% Compressive Set (ASTM D395 or D1667)	13%, maximum

3.3.2 Elastomer (urethane) shell. The elastomer shell encasing the fender cushion shall be 0.5 inch minimum thickness and shall be a polyether urethane elastomer (PTMEG) of the charasteristics listed in Table 2 and formulated to be ultraviolet inhibited.

Table 2. Urethane Elastomer Component of Shell

(a)	Shore "A" Durometer Hardness (ASTM D2240-75)	85-92
(b)	Tensile Strength (ASTM D412-80, Method A, Section 11-14)	2,000 psi minimum
(c)	Elongation (ultimate) (ASTM D412-80, Method A, Section 11-14)	500% minimum
(d)	Tear Strength (ASTM D470-81, Section 7.6)	100 lb/in.
(e)	Flex Cut Growth (Ross, flexes to 5x cut growth, ASTM D1052-55)	10,000 flexes minimum
(f)	Abrasion Resistance, NBS Abrader (ASTM D1630-61)	125 minimum
(g)	Weatherometer Aging - 500 hours (ASTM D750-68)	Minimum 60% retention of original values of specification items (a) through (d) above

3.4 Interchangeability. All fenders of the same classification furnished with similar options under a specific contract shall be identical to the extent necessary to insure interchangeability of component parts, assemblies, accessories, and spare parts.

3.5 Design. The components of the fender system shall be as described herein.

3.5.1 General configuration (without chain and tire net). The fender shall have a cylindrical mid-body with curved ends. The mid-body shall have a minimum diameter of 6.0 feet ±1.5 inches. Fender length shall be 12.25 feet ±6 inches. The fender shall be manufactured with a fabricated core of closed cell foam (see 3.3.1), encased in an elastomer-shell (3.3.2). The fender shall have no solid (non-compressible) interior longitudinal strength member connecting the fender end fittings.

Table 3. Fender Performance Parameters

Size	6-ft diameter x 12-ft long
Energy Absorption at 60% compression	210,000 ft-lb minimum
Reaction Force at the 210,000 ft-lb energy absorption point	160,000 lb maximum

3.5.2 Fender Skin Construction. The skin of the fender shall be constructed of polyurethane elastomer (see Table 2) to form a fender shell having a minimum thickness of 0.5 inches. The contractor shall certify that any seam of the fender is produced in such a manner as to assure a continuous homogeneous skin, with joint strength equal to that of the rest of the fender shell. Up to 12 filament reinforcing wraps of nylon tire cord may be used at the contractor's option. If filament wraps are used they shall be evenly distributed and the elastomer shall be applied in a continuous manner to assure adhesion between the various layers.

3.5.3 Fender Net. The fenders shall be equipped with an outer support net of inter-connected circumferential and longitudinal galvanized chains. Tires are installed at each intersection of the circumferential and longitudinal chains by passing the chain through four holes punched through the tire tread. The intersection areas (tire centers) shall connect the chains using screw pin shackles. The chains in the fender net shall terminate in a galvanized end fitting (as specified), located at each end of the fender on the longitudinal axis of the fender. All chains between the tires and end fittings shall be covered by 2-inch ID, 2-7/8-inch OD rubber sandlasting elastomer hose with 1/4-inch wall black rubber tube lining or 5/16-inch polyurethane elastomer hose having the characteristics of Table 2. All metal hardware shall be hot-dipped galvanized in accordance with ASTM A-153-78 or ASTM A-123-78 as appropriate. The chain size, strength, number of chains, and end fitting shackle size are as follows:

Chain Size	- 7/16 in. minimum
Ultimate Strength	- 26,200 lb minimum
Number of Longitudinal Chains	- 5 minimum
Number of Circumferential Chains	- 3 minimum
Shackle Size	- 1.25 in. minimum

The fender net and end fittings shall be designed for a working load of 12 tons.

3.5.4 End Fittings. The end fittings shall be sized for a 1-inch minimum shackle and shall be designed to transmit the ultimate load of the shackle to the fender. The end fittings shall be cast ductile iron or fabricated A-36 steel and hot-dipped galvanized in accordance with ASTM A-153 or ASTM A-123.

3.5.5 Color. The fender skin color shall be black. Galvanized metal hardware shall be unpainted.

3.5.6 Repairability. The fender casing shall be repairable in the event of tears or punctures in the urethane shell. The repaired area shall have not less than 90% of the properties as specified in 3.3.2. Required repair materials shall be readily available from the fender manufacturer.

3.6 Workmanship.

3.6.1 Urethane Shell. The urethane shell of the fender shall be free from cracks, burrs, warpage, checks, chipped, or blistered surfaces and shall have a smooth surface.

3.6.2 Steel Fabrication. The steel used in fabrication shall be free from kinks, sharp bends, and other conditions which would be deleterious to the finished product. Manufacturing processes shall not reduce the strength of the steel to a value less than intended by the design. Manufacturing processes shall be done neatly and accurately. All bends shall be made by controlled means to insure uniformity of size and shape.

3.6.3 Foam Core. The foam core shall be homogeneous and of one piece fabricated construction and shall not be in chip or granular form, neither lose packed nor bound with a discontinuous filler material.

3.6.4 Welding. Welding procedures shall be in accordance with a nationally recognized welding code. The surface of parts to be welded shall be free from rust, scale, paint, grease, or other foreign matter. Welds shall be of sufficient size and shape to develop the full strength of the parts connected by the welds. Welds shall transmit stress without permanent deformation or failure when the parts connected by the weld are subjected to proof and service loadings.

3.7 Inspection System. The contractor shall establish an inspection system in accordance with MIL-I-45208.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. Unless otherwise specified herein, the contractor is responsible for the performance and cost of all inspection and test requirements. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection and test requirements specified unless disapproved by the Government. The First Article test report shall be signed by an authorized Government representative as evidence that the examination and tests were witnessed by the representative and that the results were reported therein. The Government

reserves the right to perform or witness any of the inspections or tests set forth in the specification where such inspections or tests are deemed necessary to assure that the fenders conform to prescribed requirements. Upon completion of all inspection and test requirements, the contractor will certify in writing, with notorized copies of all results, to the procurement office that all inspections and tests were performed as required and that the fenders successfully passed all inspections and tests as specified herein.

4.2 Classification of Inspection. Inspection shall be classified as follows:

(a) First article inspection (see 3.1 and 4.2.1)

(b) Quality conformance inspection (see 4.2.2)

4.2.1 First Article Inspection. First article inspection shall be performed on a complete contract item. This inspection shall include the examination of 4.3 and tests of 4.4.

4.2.2 Quality Conformance Inspection. Quality conformance inspection shall be performed on each item in accordance with the examination of 4.3 and 4.4.5.

4.3 Examination. Each contract item shall be examined for compliance with the requirements specified in Section 3 of this purchase description. This element of inspection shall encompass all visual examinations and

dimensional measurements. Records maintained in accordance with 3.7 shall be inspected by the Government to verify that the materials used in construction of all contract items conform to the requirements stated herein. Any redesign or modification of the contractor's product to comply with specified requirements, or any necessary redesign or modification following failure to meet specified requirements shall receive particular attention for adequacy and suitability. Noncompliance with any specified requirements or presence of one or more defects preventing or lessening maximum efficiency shall constitute cause for rejection.

4.4 Tests. The First Article shall be tested to determine compliance with this purchase description. Tests shall be conducted as specified in 4.4.1 through 4.4.4.

4.4.1 Fender. The following tests apply to an assembled fender.

4.4.2 Energy Absorption Capacity and Reaction Force. The First Article fender shall be compressed between two parallel flat plate surfaces to 40% of its original diameter (this shall be referred to as the 60% compression point) by an evenly distributed load, perpendicular to its longitudinal axis at a rate not less than 2.4 inches per minute. The load and corresponding deflection shall be recorded at one-inch increments and plotted on a graph of load versus deflection. The load deflection curve shall then be integrated to generate an energy-deflection curve for the fender. At the 60% compression point (deflection of 43.2 inches) on the energy-deflection curve, the energy absorption shall be not less than 210,000 ft/lb. Upon release of the load, the fender

shall show no sign of permanent distortion, rips, tears, delaminations, or other defects. Thirty minutes after release of the compression load visible permanent deformation of elongation of the fender or compression set exceeding 4% (relative to the start of the test) shall constitute failure of the test. The reaction force shall be that force required to deflect the fender to its rated energy absorption of not less than 210,000 ft/lb. This force shall be taken from the force-deflection curve and shall not exceed 160,000 pounds.

4.4.3 Overload and Durability Test. The fender (without chain and tire net) shall be compressed between two parallel flat plate surfaces to 80% of its original diameter (to an overall thickness of 14.4 inches) by an evenly distributed load perpendicular to its longitudinal axis at a rate not less than 2.4 inches per minute. The load shall be immediately removed and the fender shall be rotated and compressed 80% again. This test shall be repeated two additional times for a total of three rotations (four compressions). Upon completion of this test the fender shall show no signs of rips, tears, or delaminations.

4.4.4 Axial Test. The fender (without chain and tire net) shall be compressee between two parallel flat plate surfaces to 75% of its original length (overall height of 108 inches) by an evenly distributed load parallel to its longitudinal axis at a rate not less than 2.4 inches per minute. The load shall be immediately removed and the fender shall be compressed 75% again. This test shall be repeated three times (for a total of four compressions) within a 150-minute period beginning with the first 20% compression. Upon completion of this test the fender shall show no sign of rips, tears, or delaminations.

4.4.5 Urethane Elastomer Retains. Test Coupons of the Urethane Elastomer used to manufacture each fender shall be identified and retained by the contractor for a period of not less than 5 years from the date of fender manufacture. A coupon from every third fender of the lot shall be submitted to an independent laboratory for physical testing in accordance with Paragraph 3.3.2 (a)-(d). An example of coupon selection is fender 1, 4, 7, 10, 13 etc. The certified test results of these tests are to be submitted to the Cognizant Contract Quality Control Representative for approval. The government reserves the right to request any of the remaining specimens within the 5 year period and perform any or all of the tests of 3.3.2 at government expense. The test coupons shall be 36 sq in. minimum by .09 ± .03 inches thick.

4.4.5.1 Collection fixture.

(a) If fender skin is cast in a mold, the fixture shall be a mold of the above minimum dimension.

(b) If fender skin is built up by spraying, the fixture shall be a flat plate of 36 sq in. area or greater.

4.4.5.2 Fixture preparation. The appropriate fixture with release agent applied is to be at the same temperature as the fender skin when formed.

4.4.5.3 Coupon collection.

(a) If the fender skin is cast in a mold, the coupon mold is to be filled with liquid urethane collected from the pour stream at the mold fill point.

(b) If the fender skin is built-up by spraying, the collection fixture is to be passed through the spray stream so that one layer, equivalent to one layer of urethane on the fender shell, is applied. This procedure is to be repeated until the specified coupon thickness is achieved. The time between coats is to be the same as the time between layers applied to the fender shell.

4.4.5.4 Coupon curing. The coupon is to be cured under the same conditions as the fender shell.

4.4.5.5 Frequency of Collection. One or more coupons are required for each fender as specified below.

(a) If cast in a mold, one coupon is required for each component cast, i.e., ends, cylinder, joints, etc.

(b) If sprayed, a minimum of one coupon, representative of the skin cross section, is required.

APPENDIX C

A SITE SPECIFIC STUDY, LIFE CYCLE COST COMPARISON OF NAVY FLOATING PIER AND PILE-SUPPORTED PIER

1.0 INTRODUCTION

This study compares the Navy Floating Pier conceptual design, with a typical fixed, single-deck, pile-supported pier of the latest Navy design. The comparison is intended to provide a suggested methodology for analyzing costs, and an example of typical costs that may be assigned to construction and operations and maintenance of a floating pier versus the standard Navy, single deck, fixed-pile supported pier. The Port of Seattle was used as the site and its physical characteristics are used for both piers, even though the tidal range is somewhat greater than at most naval ports in the US.

The following paragraphs describe the characteristics common to both alternatives and the overall physical characteristics of each pier.

1.1 Characteristics Common to Both Piers

Each pier alternative has the following characteristics:

- 1200 foot usable length, providing four berths alongside for CG/CGN, DD/DDG, FF/FFG type ships. Nesting of one additional ship at each berth is accommodated.
- A Med-moor at the seaward end for an AD-41 class Destroyer Tender.
- Utility capacities provide for eight ships at the pier, four alongside plus four nested, and the Destroyer Tender with "pass-through" capacity for four ships alongside the tender. A total of 12 surface combatant ships and the tender are accommodated.
- The environmental and geotechnical conditions are taken as follows:

Tidal Range:

Tide	Elevation (Feet)
Extreme High Water	14.7
Mean Higher High Water	11.7
Mean High Water	10.8
Mean Tide Level	6.8
Mean Sea Level	6.4
Mean Low Water	2.8
Mean Lower Low Water	0
Extreme Low Water	-4.5

Currents: negligible.

Design Wind Conditions:

Direction	Maximum Wind Velocity
South	70 mph
Southwest	70 mph
West	45 mph

Design Wave Characteristics:

Direction	Significant Wave H_S	Significant Wave T_S
South	3-1/2 feet	3.7 seconds
Southwest	3 feet	4.5 seconds
West	2-1/2 feet	3.2 seconds

Geotechnical Conditions:

A dense sand down to elevation (-)90.0 feet mean lower low water (MLLW) with saturated unit weight of approximately 130 pounds per cubic foot (pcf) and an angle of internal friction of 36 degrees. The dense sand is underlain by a stiff clay with undrained shear strength of 2,500 pounds per square foot (psf) and a saturated unit weight of approximately 130 pcf.

1.2 Navy Floating Pier

The general description of the floating pier includes:

- A two-deck pier with the lower portion a pontoon section 75 feet (ft) wide by 18 feet deep. Bulkheads are spaced at 40 feet. The pontoon section is constructed in 400-foot long modules and joined at the site. The roof of the pontoon section is the lower deck of the pier which has a freeboard of 5 to 7 feet.

- The superstructure forms the pier main deck which is 15 feet above the lower level and 65 feet wide.

- Utilities are located in galleries on the lower level. Vehicular access parallels the galleries the length of the pier on either side. The center portion of the lower deck contains transformer vaults, storage, etc.

- The pier is restrained horizontally by two-pile bents every 40 feet. The pier floats vertically on the piles.

- Three ramps connect the pier to shore abutments. The center ramp serves the main deck, with two side ramps leading to the vehicle corridors of the lower deck.

1.3 Pile-Supported Pier

The fixed pier alternative is generally described as follows:

- A single-deck pier of conventional concrete construction, supported by precast, prestressed concrete piles. The pier is 120 feet wide curb-to-curb. The pier is connected to the shore with a 50-foot section to provide a full 1200 feet of berthing.

- In accordance with DM-25.1, the pier deck elevation is 18 feet above MLLW. This elevation is level with adjacent land.

- The fender system design is conventional timber fender piles and timber walers, with rubber cylindrical energy absorbing units between the pier deck and fender system.

- Transformer/switchgear vaults are suspended underneath the deck. Mechanical system piping is located in a utility trench on the outer edges of the pier. The trench cover is removable. Utility service outlets are above deck.

- The Destroyer Tender Mediterranean moor, and mooring hardware are essentially the same on both piers.

2.0 LIFE CYCLE COST ELEMENTS

The elements estimated in the LCC are in four categories: acquisition, pier operations, maintenance and repair, and terminal value. The following paragraphs provide comments on the cost elements and document the estimates.

2.1 Acquisition

Since the purpose of this study is the comparison of the Navy floating pier design with the current Navy "standard" pier design, the construction cost estimates should be made on the basis of identical conditions and should vary only where affected by the differences in design. The floating pier estimate is shown in table C-1. The pile-supported pier construction cost estimate is contained in table C-2.

Construction cost estimates were confined to the pier proper and its immediate interface with the shore. Landside site preparation or utilities are not included since they are totally site specific and will not vary with the pier design.

The significant differences in construction costs are as follows:

Item	Floating Pier	Fixed Pier
Mobilization	$ 310,000	100,000
Piling	2,300,000	5,942,400
Fender System	1,315,200	945,000
Pier Structure	10,314,500	5,085,000
Abutment/Ramps	1,430,600	356,000
	$15,670,300	$12,428,400

2.2 Pier Operations

Based on the NCEL Pier Utilization Study, the following pier operational scenario was established:

- An average loading at the pier of six surface combatants, four alongside plus two nested, and the Destroyer Tender.

- Fifty surface combatant arrivals/departures per month, 16 of which are outboard nested ships. Two arrivals and two departures per year of the Destroyer Tender.

- Utility services per month:

  - 17 connections and 17 disconnections at the pier.
  - 8 connections and 8 disconnections of nested ships.

- Crane service per month:

  - 20 major lifts
  - 25 minor lifts
  - 30 brow and platform movements

- Cargo loadings:

  - 28 minor per month
  - 14 major per year

The Pier Utilization Study acquired and analyzed data for pier functions covering 58 arrivals and departures, 55 crane operations, 8 cargo loadings and other miscellaneous evolutions. From this study, labor, equipment, time and current cost data were obtained. For day-to-day pier operations, it was concluded that the significant functions that would be influenced by improved pier designs are brow placement/removal, utility connection/disconnection services, crane service, and cargo loading. Functions such as mooring line handling, solid waste disposal, and training van operations were not seen to be significantly changed by the new pier design concepts. The following paragraphs estimate operational costs for these functions performed on the two alternative piers.

The labor for utilities connection/disconnection and crane lifts does not include concomitant shipboard labor or equipment operation. The data is not available and certain elements will not be affected by the pier design . If improved pier designs decrease time required for these evolutions, shipboard labor and equipment time will decrease accordingly.

Table C-1. Construction Cost, Floating Pier

Mobilization		$310,000
Dredging		5,073,000
Pier Structure		14,008,900
Floating Structure	10,314,500	
Anchor Piles	2,300,000	
Fender System	1,315,200	
Bollards	79,200	
Abutments and Ramps		1,430,600
Concrete	100,000	
Piling	161,000	
Backfill	15,000	
Rip Rap	80,000	
Ramps	1,074,600	
Mechanical		1,597,800
Compressed Air	158,600	
Steam	335,800	
Potable Water	193,400	
Fire Main System	381,700	
Station Hose	70,700	
Sewage	171,800	
Blowers, Louvers, Ducts	64,900	
Pipe Supports	73,900	
Ramps (joints)	147,000	
Electrical		5,962,000
Lighting	141,500	
Cable	1,050,000	
Cable Terminals	182,600	
Conduit and Cable Trays	923,200	
Transformers	821,200	
Switchgear	2,317,200	
Reels	458,700	
Cathodic Protection	68,400	
Med-Moor System		335,000
Pile, Anchor	100,000	
Chain & Weights	230,000	
Buoy	5,000	
TOTAL		$28,718,100

Table C-2. Construction Cost, Fixed Pier

Mobilization		$ 100,000
Dredging		5,073,000
Piling: 74,280 LF x $80/LF		5,942,400
Pier Structure: 150,000 ft^2 x $31.90/$ft^2$ + $300K		5,085,000
Fender System: 2520 LF X $375/LF		945,000
Bollards		80,000
Abutment:		
Concrete	$100,000	356,000
Piling	161,000	
Backfill	15,000	
Rip Rap	80,000	
Mechanical:		1,681,600
Compressed Air	158,600	
Steam	431,000	
Potable Water	195,000	
Fire Main System	420,000	
Station Hose	71,000	
Sewage	206,000	
HVAC Elect. Vaults	200,000	
Electrical:		5,935,000
Lighting	91,500	
Cable	1,079,000	
Conduit	1,169,500	
Space Heaters	10,500	
Power Substations	3,287,000	
Telephone	219,000	
Fire Alarm	78,500	
Med-Moor System:		335,000
Piles, Anchor	100,000	
Chair & Weights	230,000	
Buoy	5,000	
TOTAL		$25,533,000

2.2.1 Fixed, Single-Deck Pier Operations.

a. Brow/Platform Placement and Removal. The cost for each evolution averages:

4 military @ $8/manhour (mh)	= $32
1 Crane + crew @ $90/hour (hr) x 1.3 hr (1 hr operation + 0.3 hr transit)	= $117
	$149 per evolution

Annual Cost = 30/month x 12 x $149 = $53,640

b. Utility Services.

Arrivals:

Tender = 64 mh x $23 mh x 2/year	= $ 2,944/year
Surface Combatants at pier = 28 mh x $23/mh x 17/month	= $10,948/month
Surface Combatants outboard = 33.6 mh x $23/mh x 8/month	= $ 6,182/month

Departures:

Tender = 16mh x $23/mh x 2/year	= $ 736/year
Surface Combatants at pier = 16 mh x $23/mh x 17/month	= $6256/month
Surface Combatants outboard = 19.2 mh x $23/mh x 8/month	= $3533/month

Annual Cost = $26,919 x 12 months	= $323,028
3,680 x 1	= 3,680
	$326,708

c. Crane Service. Of the 20 major lifts, five are performed by floating crane.

Floating crane:	5 lifts x $305/hr x 3.45 hr (2.25 hr operation + 1.2 hr transit)	= $5260
Mobile Crane:	15 major lifts x $123/hr x 2.55 hr (2.25 hr operation x 0.3 hr transit)	= $4705
	25 minor lifts x $90/hr x 1.3 hr (1 hr operation x 0.3 hr transit)	= $2925
		$12,890/month

Annual Cost = 12 x $12,890 = $154,680

d. Cargo Loading.

Minor @ 2 hr:

10 military x 2 hr x \$8/mh	=	\$160
3 civilian x 2 hr x \$20/mh	=	120
Truck x 2.5 hr x \$10/hr	=	25
Forklift x 2.5 hr x \$15/hr	=	38
		\$343 per loading

Major @ 5 hr:

20 military x 5 hr x \$8/mh	=	800
3 civilian x 5 hr x \$20/hr	=	300
Truck x 5.5 hr x \$10/hr	=	55
Forklift x 5.5 hr x \$15/hr	=	83
		\$1238 per loading

Annual Cost = 12 x 28/month x \$343	=	\$115,248
14/year x \$1238	=	\$ 17,332
		\$132,580

2.2.2 Floating Pier Operations.

a. Brow/Platform Placement and Removal. The floating pier design will eliminate the need for platforms in a number of cases and, coupled with improved brow designs, can eliminate the need for a mobile crane at each arrival and departure. These basic changes will enable brows to be set by hand in some cases and brows/platforms by the electrical cable handling boom truck in others. The estimated cost is:

Evolutions with boom truck:

4 military x 0.3 hrs x \$8/mh	=	\$9.60
boom truck + crew \$63/hr x 0.3 hrs	=	18.50
		\$28.10

Evolutions by hand:

8 military x 0.3 hrs x \$8/mh	=	\$19.20

Annual Cost = 15/month x \$28.10 x 12	=	\$5058
15/month x \$19.20 x 12	=	3456
		\$8514

b. Utility Services.

Arrivals:

Surface combatants at pier	= 12 mh x \$23/mh x 17/month	=	\$4692/month
Surface combatants outboard	= 14.4 mh x \$23/mh x 8/month	=	2650/month
Tender	= 24.5 mh x \$23/mh x 2/year	=	1127/year

Departures:

Tender = 13.6 mh x \$23/mh x 2/year = \$ 626/year
Surface combatants at pier = 8.6 mh x \$23/mh x 17/month = 3363/month
Surface combatants outboard = 10.3 mh x \$23/mh x 8/month = 1895/month

Annual Cost = \$12,600 x 12 months = \$151,200
+ 1,753
\$152,953

c. Crane Service. The floating pier design will improve crane service and decrease cost in two ways: (1) mobile cranes can be used where floating cranes are required for the fixed pier for certain lifts because the offset will be eliminated, and (2) smaller capacity mobile cranes can be used many times because the lift radius is less. The estimated operations costs based on the given scenario are:

Floating crane: 2 lifts x \$305/hr x 3.45 hrs = \$2105

Mobile crane:
12 major lifts x \$123/hr x 2.55 hrs = \$3,764
6 major lifts x \$105/hr x 2.55 hrs = 1,607
15 minor lifts x \$90/hr x 1.3 hrs = 1,755
10 minor lifts x \$75/hr x 1.3 hrs = 975
\$10,206/month

Annual Cost = \$10,206 x 12 = \$122,472

d. Cargo Loading. The floating pier design is seen to reduce cargo loading labor and time in two ways: (1) for hand-carried cargo, the reduction in platforms and elimination of tidal change elevation shifts will save time/manpower, and (2) the use of portable, powered conveyors will become more practical. A reduction in costs of at least 40% is estimated.

Annual Cost = \$132,580 x 0.60 = \$79,548

2.2.3 Summary of Operational Costs. Table C-3 summarizes the above cost estimates.

Table C-3. Operational Costs

Function	Quantity	Estimated Annual Cost	
		Floating Pier	Fixed Pier
Place/Remove Brows & Platforms	30 per month.	\$ 8,514	\$ 53,640

Table 2-3. Operational Costs (Continued)

Function	Quantity	Estimated Annual Cost	
		Floating Pier	Fixed Pier
Provide utility connect/disconnect	50 per month.	152,953	326,708
Crane Service	20 major lifts & 25 minor lifts per month.	122,472	154,680
Cargo Loading	28 minor per month, 14 major per year.	79,548	132,580
		$363,487	$667,608
Present Value 25-Year Life Cycle		$3.46M	$6.36M

2.3 Maintenance and Repair

Maintenance and repair life cycle cost includes both annual and cyclical costs over a 25-year period to provide for:

- Maintenance dredging
- Inspections and repairs to:
  - Pier structure
  - Piling
  - Fender system
  - Med-Moor system
- Inspection, maintenance and repairs to:
  - Mechanical systems
  - Electrical distribution system
  - Telephone system

The standards for maintenance and repair used in the estimates were based upon Navy and commercial practices, state codes and recommended manufacturers' standards for equipment and support systems. Operation and maintenance of the installed portions of the mechanical and electrical distribution systems will be similar for both types of piers.

2.3.1 Maintenance Dredging. Sedimentary deposits and silting around pier facilities in the Port of Seattle appear to be minor compared to many Navy ports. Dredging requirement for the floating pier was taken as 38,000 cubic yards at a 13 year frequency. The dredging concept was modified in two ways for the fixed, pile-supported pier:

- The volume of dredge spoils to be moved was reduced for the fixed pier to reflect a certain volume trapped under the pier, between piles.
- The frequency was changed to a 10-year cycle to account for anticipated increase in silting caused by the fixed pier structure interference with the flow stream.

2.3.2 Pier Structure. Specific maintenance and repair standard were developed for the floating pier. For the more conventional fixed, pile-supported pier, the day-to-day maintenance programs were projected as being significantly less. For the fixed pier:

- The actual structural inspection consisted of annual walk-the-pier inspection and cyclical (5 year) diver inspection of the piling. Repairs to the piles and pile caps were projected at a 15-year cycle.
- Fender piles were considered to have a 6-year life compared to 10 years used for the floating pier fender design.
- Nominal abutment repairs were planned on a 10-year cycle.
- Repairs to the Med-Moor System are the same as used in the floating pier LCC estimate.

2.3.3 Mechanical Systems. The basic maintenance and repair programs for both piers were based on experience and manufacturers' standards. The cost differences between the two types of piers include:

- For pipe repairs on the fixed, pile-supported pier for the compressed air, steam, potable water, and sewage systems, costs were added to cover the removal and replacement of concrete trench covers and repairs to pier.

- Hose replacement costs and frequency were changed for each pier design. Hose lengths of life for the fixed pier were based on actual replacement frequencies being experienced at Naval Station, San Diego, and Naval Station, Norfolk. Hose lengths of life for the floating pier are estimates based on discussions with Public Works Center (PWC) utilities management personnel, judgement, and analysis of the differences between current operations and potential operations on a two-deck pier with utility galleries.

  - For the fixed pier:

    Steam hose life.... 6 months
    Potable water hose life.... 1 year
    Sewage hose life.... 7 months

  - For the floating pier:

    Steam hose life....1 year
    Potable water hose life.... 2 years
    Sewage hose life.... 18 months

2.3.4 Electrical Systems. The basic maintenance and repair programs for installed systems on both piers reflected general experience, code requirements for underground distribution systems, and manufacturers' standards. Specific differences included:

- Lighting repairs were developed to reflect a curb type of lighting on the pile-supported pier and pole mounted fixtures on the floating pier.

- Inspection and maintenance costs for transformers, switchgear and cables were higher on the pile-supported pier than for a floating pier, because of the greater inaccessibility of the equipment.

- Cable reels and cathodic protection were required on the floating pier.

- The replacement interval for ship-to-shore cables on a pile-supported pier, was taken as 7 years, and replacement cost was translated to an annual program. The replacement program on a floating pier was assumed to be 12 years.

- A replacement program for viking plugs was also included on an annual basis on the pile-supported pier, but not on the floating pier.

2.3.5 Telephone System. Telephone maintenance was reflected as a nominal cost on the floating pier. Because of the exposure on deck mounted power mounds, greater annual costs were included for the fixed pier.

2.3.6 Summary of Maintenance and Repair Costs. Tables C-4 and C-5 provide the breakdown of maintenance and repair requirements for the floating pier and fixed pier, respectively. The comparative present value costs for maintenance and repair over the 25-year life cycle are:

Floating pier - $1,925,927

Fixed pier - $3,214,069

2.4 Terminal Value

In the Life Cycle Cost (LCC) analysis, termination can be treated two basic ways: (1) terminate costs at year 25 and consider the piers left in place with neither terminal value nor costs; or (2) return the site to its original condition and include any terminal values and costs in both alternatives. The latter method is the more conventional in economic analyses, even though at the 25th year costs do not have significant affect upon present value. In this case, the relocatable characteristic of the floating pier is a factor that should definitely be considered. Accordingly, demolition of the fixed pier is shown below and incorporates terminal value of salable material. In summary:

	Estimate	Discount Factor	Present Value
Floating Pier Salvage Value:	$16,789,470	0.097	$1,628,580
Fixed Pier Demolition Cost: $= 150{,}000\ ft^2 \times \$15.50/ft^2 =$	($2,325,000)	0.097	($225,525)

Table C-4. Floating Pier Maintenance and Repair Costs, 25-Year Life Cycle.

COST ELEMENT	FREQUENCY	DIRECT COST ($)	DISCOUNT FACTOR	PRESENT VALUE COST ($)
CIVIL/STRUCTURAL				
1. Dredging	13 years	300,000	0.304	91,200
2. Pier Structure:				
Inspection	Annual	50,000	9.524	476,200
Piling Repairs	15 years	250,000	0.251	62,750
Fender Repairs	10 years	100,000	0.405	40,500
	20 years	100,000	0.156	15,600
3. Abutment & Ramp Repairs	15 years	175,000	0.251	43,925
4. Med-Moor System Repair	10 years	115,000	0.405	46,575
	20 years	115,000	0.156	17,940
TOTAL CIVIL				$794,690
MECHANICAL SYSTEMS				
1. Compressed Air:				
Repack valves	Annual	600	9.524	5,714
Repair Pipe	15 years	13,500	0.251	3,389
2. Steam:				
Repack valves	Annual	900	9.524	8,572
Repair pipe	Annual	2,700	9.524	25,715
Replace expansion joints	5 years	4,120	0.652	2,685
	10 years	4,120	0.405	1,669
	15 years	4,120	0.251	1,034
	20 years	4,120	0.156	643
	25 years	4,120	0.097	400
Replace steam traps	Annual	800	9.524	7,619
3. Potable Water:				
Repack valves	Annual	700	9.524	6,667
Repaint pipe	15 years	17,590	0.251	4,415

Table C-4. Floating Pier Maintenance and Repair Costs, 25-Year Life Cycle (Continued).

COST ELEMENT		FREQUENCY	DIRECT COST ($)	DISCOUNT FACTOR	PRESENT VALUE COST ($)
4. Firemain:					
Repack valves		Annual	750	9.524	7,143
Paint pipe		15 years	20,435	0.251	5,129
Maint. diesel		Annual	750	9.524	7,143
Overhaul equip.		5 years	36,450	0.652	23,765
		10 years	36,450	0.405	14,762
		15 years	36,450	0.251	9,149
		20 years	36,450	0.156	5,686
		25 years	36,450	0.097	3,536
5. Sewage:					
Repack valves		Annual	600	9.524	5,714
Repaint pipe		15 years	17,590	0.251	4,415
6. Blowers Ductwork:					
Replace		Annual	700	9.524	6,667
7. Ramp Swivels:					
Replace gaskets and bearings		5 years	20,000	0.652	13,040
		10 years	20,000	0.405	8,100
		15 years	20,000	0.251	5,020
		20 years	20,000	0.156	3,120
		25 years	20,000	0.097	1,940
8. Hose Replacement:		Annual	28,420	9.524	270,672
Steam	19,250				
Potable water	2,170				
Comp. air	500				
Sewage	5,000				
Salt water	1,500				
TOTAL MECHANICAL					$463,523
ELECTRICAL SYSTEMS					
1. Lighting:					
Repair system		Annual	1,380	9.524	13,143
Replace fixtures		10 Years	14,700	0.405	5,954
		20 Years	14,700	0.156	2,293

Table C-4. Floating Pier Maintenance and Repair Costs, 25-Year Life Cycle (Continued).

COST ELEMENT	FREQUENCY	DIRECT COST ($)	DISCOUNT FACTOR	PRESENT VALUE COST ($)
2. Cables:				
Maintain and inspect equipment	Annual	8,100	9.524	77,144
Replace cables	Annual	28,500	9.524	271,434
Hi-Pot tests	5 years	3,800	0.652	2,478
	10 years	3,800	0.405	1,539
	15 years	3,800	0.251	954
	20 years	3,800	0.156	593
	25 years	3,800	0.097	369
3. Cable Trays/Conduit:				
Inspect & paint	Annual	5,000	9,524	47,620
Replace supports	15 Years	7,500	0.251	1,8834
4. Transformers:				
Check oil/tanks	Annual	1,800	9.524	17,143
Test equip/filter oil	5 Years	24,700	0.652	16,104
	10 Years	24,700	0.405	10,004
	15 Years	24,700	0.251	6,200
	20 Years	24,700	0.156	3,853
	25 Years	24,700	0.097	2,396
5. Switchgear:				
Test CBs, controllers, inspect buses.	Annual	8,800	9.524	83,811
Clean, test and adjust CBs, relays.	5 Years	16,000	0.652	10,432
	10 Years	16,000	0.405	6,480
	15 Years	16,000	0.251	4,016
	20 Years	16,000	0.156	2,496
	25 Years	16,000	0.097	1,552
6. Cable Reels:				
Repair	Annual	5,800	9.524	55,239
7. Cathodic Protection:				
Clean & test	Annual	900	9.524	8,572
Replace units	10 Years	15,900	0.405	6,440
	20 Years	15,900	0.156	2,480
TOTAL ELECTRICAL				$ 662,622
TELEPHONE REPAIR	Annual	500	9.524	4,762
GRAND TOTAL				$1,925,597

Table C-5. Fixed Pier Maintenance and Repair Costs, 25-Year Life Cycle.

COST ELEMENT	FREQUENCY	DIRECT COST ($)	DISCOUNT FACTOR	PRESENT VALUE COST ($)
CIVIL/STRUCTURAL				
1. Dredging	10 years	272,500	0.405	110,363
	20 years	272,500	0.156	42,510
2. Pier Structure:				
Inspection	Annual	500	9,524	4,762
Piling inspection	5 years	10,000	0.652	6,520
	10 years	10,000	0.405	4,050
	15 years	10,000	0.251	2,510
	20 years	10,000	0.156	1,560
	25 years	-	0.097	
Structure repairs	15 years	105,000	0.251	26,355
Fender replacement	6 years	900,000	0.592	532,800
	12 years	900,000	0.334	300,600
	18 years	900,000	0.189	170,100
	24 years	-	0.107	-
3. Abutment repairs	10 years	45,000	0.405	18,225
	20 years	45,000	0.156	7,020
4. Med-Moor System repairs	10 years	115,000	0.405	46,575
	20 years	115,000	0.156	17,940
TOTAL CIVIL/STRUCTURAL				$1,291,890
MECHANICAL SYSTEMS				
1. Compressed Air:				
Repack valves	Annual	600	9.524	5,714
Repair pipe	15 Years	34,300	0.251	8,609
2. Steam:				
Repack valves	Annual	900	9.524	8,572
Repair pipe	Annual	17,100	9.524	162,860
Replace expansion joints	5 Years	5,000	0.652	3,260
	10 years	5,000	0.405	2,025
	15 years	5,000	0.251	1,255
	20 years	5,000	0.156	780
	25 years	-	0.097	

Table C-5. Fixed, Pile Maintenance and Repair Costs, 25-Year Life Cycle (Continued).

COST ELEMENT		FREQUENCY	DIRECT COST ($)	DISCOUNT FACTOR	PRESENT VALUE COST ($)
3. Potable Water:					
Repack valves		Annual	630	9.524	6,000
Repair pipe		15 years	38,790	0.251	9,736
4. Firemain:					
Repack valves		Annual	730	9.524	6,952
Repair diesel engine		Annual	750	9.524	7,143
Overhaul equip		5 years	36,450	0.652	23,765
		10 years	36,450	0.406	14,762
		15 years	36,450	0.251	9,149
		20 years	36,450	0.156	5,686
		25 years	-	0.097	
Repair pipe		15 years	24,435	0.251	5,631
5. Sewage System:					
Repack valves		Annual	600	9.524	5,714
Repair pipe		15 years	38,790	0.251	9,736
6. Blowers/Ductwork louvers-replacement		Annual	700	9.524	6,667
7. Hose					
Replacement:		Annual	61,700	9.524	587,631
Steam hose	38,500				
Potable water	4,350				
Comp. air	2,000				
Sewage	12,850				
Salt water	4,000				
TOTAL MECHANICAL					$891,647

ELECTRICAL SYSTEMS

COST ELEMENT	FREQUENCY	DIRECT COST ($)	DISCOUNT FACTOR	PRESENT VALUE COST ($)
1. Lighting Repairs	Annual	6,000	9.524	57,144
2. Cables:				
Test 15 KV cable	Annual	1,000	9.524	9,524
Hi-Pot 15 KV cable	5 years	4,500	0.652	2,934
	10 years	4,500	0.405	1,823
	15 years	4,500	0.251	1,130
	20 years	4,500	0.156	702

Table C-5. Fixed, Pile Maintenance and Repair Costs, 25-Year Life Cycle (Continued).

COST ELEMENT	FREQUENCY	DIRECT COST ($)	DISCOUNT FACTOR	PRESENT VALUE COST ($)
Inspect & Repair 600V cable mounds/plugs	Annual	19,000	9.524	180,956
Replace ship/shore	Annual	49,000	9.524	466,676
Inpect terminals/controller	Annual	3,000	9.524	28,572
3. Cable Trays/conduits: inspect and repair	Annual	3,000	9.524	28,572
4. Transformers:				
Check oil/tank etc.	Annual	2,500	9.524	23,810
Test & filter oils	5 years	32,000	0.652	20,864
	10 years	32,000	0.405	12,960
	15 years	32,000	0.251	8,032
	20 years	32,000	0.156	4,992
5. Switchgear:				
Test CBs/controllers etc.	Annual	10,500	9.524	100,002
Clean, test, & adjust controllers, CB's etc	5 years	18,000	0.652	11,736
	10 years	18,000	0.405	7,290
	15 years	18,000	0.251	4,518
	20 years	18,000	0.156	2,808
	25 years	-	0.087	
6. Switchgear: (cont) Paint enclosures, replace receptacles	10 years	31,000	0.405	12,555
	20 years	31,000	0.156	4,836
TOTAL ELECTRICAL				$ 992,436
TELEPHONE SYSTEM				
Repairs to telephone jacks on mounds	Annual	4,000	9.524	$ 38,096
GRAND TOTAL				$3,214,069

3.0 LIFE CYCLE COST COMPARISON

Table C-6 summarizes the life cycle cost estimates which result in a net present value (NPV) advantage for the floating pier of about $2.85 million. The fixed pier costs less initially, but the floating pier has significant advantages in operations, maintenance and terminal value. The following examines potential variances in the estimates and impact upon the LCC.

3.1 Cost Estimate Variances

3.1.1 Construction Costs. The estimated variance in the construction cost estimate for the floating pier, following a close analysis, was taken as + 0.7 percent; a negligible variance for this comparison. The estimated variance for the pile-supported pier was predicted to be ± 2%.

3.1.2 Operational Costs. The operational costs for the fixed pier are based on actual observations of manning, measured times, and current costs. The number of samples was suffuciently large for statistical inferences above a 95% confidence level.

The operational estimates for the floating pier were derived from current operations costs and adjusted by judgment and analyses discussed in paragraph 2.2. The accuracy of the assumptions made, and therefore the cost estimates, depends much upon how the naval activity would actually utilize the double-deck floating pier. The cost differences shown are practical and considered accurate within ± 10% or less.

3.1.3 Maintenance and Repair Costs. Following extensive analysis, maintenance and repair variances of ± 10% were developed for both pier options. For this comparative analysis, the costs are considered to be very accurate relative to each other, which is the important point here. Absolute costs were not intended in the estimate.

Table C-6. Life Cycle Cost Comparison of Floating and Fixed Piers.

COST ELEMENT	PROJECT YEAR	ESTIMATED COST FLOATING PIER	ESTIMATED COST FIXED PIER	DISCOUNT FACTOR	PRESENT VALUE FLOATING PIER	PRESENT VALUE FIXED PIER
ACQUISITION:	0	$	$	1.000		
Mobilization		310,000	100,000			
Dredging		5,073,000	5,073,000			
Pier Structure		14,008,900	12,052,400			
Abutment/Ramps		1,430,600	356,000			
Mechanical		1,597,800	1,681,600			
Electrical		5,962,800	5,935,000			
Med-Moor System		335,000	335,000			
		$28,718,100	$25,533,000		$28,718,100	$25,533,000
PIER OPERATIONS:	1-25			9.524		
Brows/Platforms		8,514	53,690			
Utility Services		152,953	326,708			
Crane Service		122,472	154,680			
Cargo Loading		79,548	132,580			
		$ 363,487	$ 667,608		3,461,850	6,358,300
MAINTENANCE AND REPAIR:	1-25	NOTE 1	NOTE 1	9.524		
Civil/Structural		83,441	135,647			
Mechanical		48,669	93,620			
Electrical		69,574	104,204			
Telephone		500	4,000			
		$ 202,184	$ 337,471		1,925,600	3,214,100
TERMINAL COST/(VALUE)	25	(16,789,470)	2,325,000	0.097	(1,628,580)	225,525
NET PRESENT VALUE OF 25-YEAR LIFE CYCLE COST					$32,476,970	$35,330,925

3.1.4 Terminal Costs/Value. The demolition cost for the fixed pier adds less than 1% to the overall net present value, so the accuracy has negligible impact on the analysis. A variance of 25% in the estimate changes the present value by only $60,000. The estimate is, consequently, sufficiently accurate such that an expected variance will have no discernible affect on the analysis.

Terminal value for the floating pier is considered to be fair and reasonable. An overall value of 58.6% of construction cost was assigned which reduces the overall net present value by less than 5%. It seems obvious that the floating pier will have a relatively high value at the end of 25 years with the very practical potential of relocation and reuse at an economical price.

The assignment of a terminal value is largely subjective and pure judgment. Any value from 0 to the $16.8 million used will vary the total present value by only 4.7%. If terminal value and costs are ignored, the net present values are $34.1 million for the floating pier and $35.1 million for the fixed pier.

3.2 Sensitivity Analysis

Table C-7 depicts the potential cost estimate variances discussed above and translates the variances to NPV ranges and the spread for each cost elements' contribution to NPV. For this analysis, a ± 10% variance was assigned to the maintenance and repair estimates.

Based on these estimates of variance, the "worst case" comparative results would be NPV's of $34.8M - floating pier, and $33.8M - fixed pier. This result assumes no terminal value for the floating pier, all variances in the positive direction for the floating pier and all variances in the negative direction for the fixed pier. This is an unconceivable set of circumstances.

The probabilities are overwhelming that the variances would be mixed, some positive, some negative, for both alternatives. The only logical prediction that can be derived is represented by the mid-point estimates, which are reflected in table C-6. The exception is the judgmental assignment of a terminal value for the floating pier as discussed in paragraph 3.1.4.

In summary:

- Swings in construction costs will impact the comparison far more than all other costs combined; more so, however, for the floating pier than the fixed pier. Even so, any variance is expected to be in the same direction for both alternatives keeping the relative comparison essentially unchanged.
- Operational costs impact the fixed pier LCC in twice the rate as the floating pier. Accuracy of the estimate for the fixed pier is considered much better with one-half as much chance for variance. The greater portion of the difference in operational costs between the pier designs is considered highly accurate.
- Similarly, maintenance and repair costs are considered extremely accurate relative to each other. Variances will change the estimates for both piers in the same direction with little or no impact on the comparison.
- A 60% terminal value for the floating pier reduces the NPV by only 5%. Lesser assigned value will have a correspondingly decreased impact on the total. The fixed pier terminal costs have negligible affect on the comparison.

Table C-7. Cost Estimate Variances and Present Value Ranges

COST ELEMENT	FLOATING PIER					FIXED PIER				
	ESTIMATE VARIANCE			PRESENT VALUE RANGE	CONTRIBUTION TO NPV	ESTIMATE VARIANCE			PRESENT VALUE RANGE	CONTRIBUTION TO NPV
	Low	Mid	High			Low	Mid	High		
Acquisition	$28.7 0	28.7	28.9 +0.7%	28.7-28.9	85 - 88%	25.2 -1.5%	25.5	25.7 +0.5%	25.2-25.7	71 - 73%
Operations	$0.32 -10%	0.36	0.40 +10%	3.05-3.81	9 - 12%	0.64 -5%	0.67	0.70 +5%	6.1-6.7	18 - 19%
Maint. & Repair	$0.18 -10%	0.20	0.22 +10%	1.71-2.10	5 - 6%	0.31 -10%	0.34	0.37 +10%	2.9-3.5	9 - 10%
Terminal Value	$0 -100%	16.8	16.8 0	0-(1.6)	0 - (5)%	2.1 -10%	2.3	2.6 +10%	0.20-0.25	0.7%

APPENDIX D

PIER DESIGN EVALUATION SYSTEM

1.0 OVERVIEW

Different types of pier designs are being developed to solve some of the current problems of ships at berth. The first designs are concentrating on a pier to serve the following types of ships:

AD	Destroyer Tender
CG	Guided Missile Cruiser
DD	Destroyer
DDG	Guided Missile Destroyer
FF	Fast Frigate
FFG	Guided Missile Fast Frigate

It is not practical to construct various designs and test efficiency, lifecycle costs, etc. Also, the characteristics that make one design better than another are numerous, varied, and in some cases conflicting. The task of comparing designs is more complex than determining which one "looks the best." The number of variables are great and each affects performance of the pier to a different degree.

The following presents an objective, systematic method for assessing and rating alternative designs of piers and pier components. It provides a framework for:

- Deciding which characteristics and performance features are to be included in the assessment.
- Numerically scoring the design and performance features including value judgments of qualitative factors.
- Weighting the evaluation factors so that the score assigned will contribute to the rating to the degree of importance desired.

The designs evaluated must be feasible, practical, and meet the basic structural design parameters. Only qualified designs will be evaluated, so the system is concerned with comparing performance and efficiency of the alternative designs.

The evaluation system is a hierarchy of factors to be assessed, measured, and scored. The methodology provides for comparing two designs with each other, or comparing a new design with an existing pier. Many important evaluation factors require rating by judgment and qualitative analysis. In addition to scoring each factor, the evaluator assigns weights to the factors to control the impact each scored factor will have on the final rating.

2.0 EVALUATION FACTORS

The evaluation factors are developed in a hierarchy beginning with the broadest categories that cover all aspects to be rated. Each category is then subdivided until a level is reached that can be measured/analyzed and scored

with a degree of confidence. Only the lowest level factors in each breakdown are measured/scored, but each level is weighted to arrive at the weight to be multiplied by the score of each factor. Table D-1 contains the list of evaluation factors with comments.

3.0 MEASURING, ANALYZING, AND SCORING THE FACTORS

In developing evaluation factors for comparison of pier designs, the primary consideration is to cover all important performance requirements of the berthing system. If the quantity of a factor can be measured or estimated, fine, but the evaluation should not be limited to those factors that can be arithmetically measured. Judgmental analysis, experience, and common sense play a valid role in comparing alternatives and can be expressed in numerical terms. A number of the factors require analysis and scoring by judgment.

Even for factors that are measurable, it is not absolutely necessary to have the measure in the units applicable to that factor. In many cases, an educated estimate of the relationship between the alternatives will serve satisfactorily.

Paragraph 6.0 contains methodology for measuring and scoring the evaluation factors. There are five scoring methods used, and a range of 0 to 10 is the scoring convention:

- Scoring based on judgment and experience.
- "Yes - No" factors scored 0 or 10.
- Scoring alternatives against each other, with the best design set at 10. The alternatives are scored relative to the best.
- Scoring the alternatives relative to a norm, or par, that is assigned a value between 0 and 10.
- Scoring against a norm that is set at 0. This method says any design that is not better than the norm does not score in that factor. An example is time required to tie up the ship. If the design does not improve the average time required today, it scores 0.

4.0 WEIGHTING THE FACTORS

Weights express the evaluator's judgment of the relative importance of each performance criteria. The conventional system of 0 to 1.0 is used. The hierarchy of factors is weighted from top to bottom with each level weighted to total 1.0 - or 100%. The multiplication of weights assigned at each level results in an effective weight for each scored factor. By necessity, the effective weights of all scored factors total to 1.0.

Since the perfect score for any factor is 10, when all scores are multiplied by their effective weights the design is rated on a base of 10. The following is an example of weighting the factors. Figure D-1 provides a form for use in weighting the factors.

TABLE D-1. PIER DESIGN EVALUATION FACTORS

LEVEL ONE	LEVEL TWO	LEVEL THREE	REMARKS
			NOTE: Numbered factors are those to be scored.
BERTHING			This group of evaluation factors measures the pier's capability to accept and berth the ships.
	Capacity		
		1. Ships at berth	
		2. Nesting capacity	
	Utilization of Area	3. Water area	In many cases, the pier site is fixed. The design must efficiently utilize the limited water and land areas available. The future new pier at Charleston is a good example.. Other factors being equal, the design that requires the least areas is preferred.
		4. Land area	
	Restraint System	5. Compatible with line patterns	While the ship restraint system must accommodate several sizes of ships, the design should not call for some arbitrary even spacing that is "blind" to the line patterns.
		6. Tie-up/line tending time	Time required is related to compatibility of design with line patterns, but will provide a measure of crew labor required.
	Fendering	7. Effectiveness/protects hull	Protection of ship is first priority; pier is secondary.
		8. Life expectancy	
		9. Ease of repair	
		10. Eliminate camels	Camels are expensive operational and maintenance items.

TABLE D-1. PIER DESIGN EVALUATION FACTORS (Continued)

LEVEL ONE	LEVEL TWO	LEVEL THREE	REMARKS
PIER CONFIGURATION			This group measures those characteristics more or less determined by the configuration/shape of the pier. It is intended to provide a valid comparison between very dissimilar designs.
	11. Clear usable deck space		Measures efficiency of design in providing working space per unit of area.
	Main Deck Elevation		These factors measure operational effectiveness of elevation design. It is assumed that design satisfies constraints of tide/wave elevations and relationships to land.
		12. Relative to MLW	
		13. Relative to MHW	
	Ship Arrival/ Departure	14. Tug assist. required	Even though tugs may be used as a matter of course, the design that permits unassisted *berthing is an advantage.*
		15. Safety of approach	
	16. Heavy lift and load service		An overall evaluation of the efficiency of the design to provide or accommodate crane service, mechanical conveyors and otherwise provide for off-on load functions.
UTILITIES	Connect/Disconnect	17. Time/labor required	The utility factors measure service to ships, requirements of the utility operation/maintenance organization and efficiency of the physical design.
		18. Safety	Applicable to electrical, steam.
		19. Spill protection	Applicable to fuel, sewage, oily waste.
	20. Efficiency of supply location/cable hose runs		

TABLE D-1. PIER DESIGN EVALUATION FACTORS (Continued)

LEVEL ONE	LEVEL TWO	LEVEL THREE	REMARKS
UTILITIES (Cont'd)	21. Accessibility/ease of maintenance		
	22. Protection from damage		
	23. Expansion potential		The following utilities required on the pier will be evaluated. 1. Electrical 2. Potable Water 3. Steam 4. Sewage 5. Oily Waste 6. Compressed Air 7. Telephones 8. TV/Data Lines 9. Salt Water 10. Fuel
CONSTRUCTION	24. Compatible with current methods		A design requiring construction methods unique to those in use will be difficult and costly to execute.
	Time	25. Total construction time	
		26. On-site time	Applicable to those designs that allow pre-fabrication of pier components off-site, thereby, reducing on-site time.
UNIQUE DESIGN FEATURES			This category provides for adding evaluation factors unique to a design that are not covered by the other categories.

4.1 Assigning Weights for Evaluation Factors. Based on your experience with current pier and ship berthing problems, weight the pier design evaluation factors to reflect their importance.

a. First, weight the five Level One categories on the basis of 1.0

	EXAMPLES ONLY
Berthing	0.25
Pier Configuration	0.20
Utilities	0.25
Construction	0.15
Unique Design Features	0.15
	1.00

b. Next, go to Level Two factors and weight those:

	EXAMPLES ONLY
Capacity	0.30
Utilization of Area	0.15
Restraint System	0.20
Fendering	0.35
	1.00

c. Third, weight the Level Three factors within each Level Two on the basis of 1.0.

	EXAMPLES ONLY
Ships at berth	0.60
Nesting capacity	0.40
	1.00
Water Area	0.70
Land Area	0.30
	1.00
Compatible with line patterns	0.50
Tie-up/line tending time	0.50
	1.00
Effectiveness	0.30
Life expectancy	0.25
Ease of repair	0.30
Eliminate camels	0.15
	1.00

d. The effective weight for each scored factor is the product of the heirarchy of weights assigned. Example: Ships at berth = 0.25 (Level one) x 0.30 (Level two) x 0.60 (Level three) = 0.045 is the effective weight for factor 1.

WEIGHTING PIER DESIGN EVALUATION FACTORS

PIER DESIGN: ______________________

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EVALUATION FACTORS						EFFECTIVE WT.
LEVEL ONE	WT #1	LEVEL TWO	WT #2	LEVEL THREE	WT #3	#1 X #2 X #3
BERTHING						
		Capacity		1. Ships at berth 2. Nesting capacity	1.00	
		Utilization of Area		3. Water area 4. Land area	1.00	
		Restraint System		5. Compatible with line patterns 6. Tie-up/line tending time	1.00	
		Fendering	1.00	7. Effectiveness/protects hull 8. Life expectancy 9. Ease of repair 10. Eliminate camels	1.00	
PIER CONFIGURATION						
		11. Clear usable deck space				
		Main Deck Elevation		12. Relative to MLW 13. Relative to MHW	1.00	
		Ship Arrival/ Departure		14. Tug assist. required 15. Safety of approach	1.00	
		16. Heavy lift and load service	1.00			

Figure D-1. Factor Weighting Form

WEIGHTING PIER DESIGN EVALUATION FACTORS

PIER DESIGN: ______________________

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EVALUATION FACTORS						EFFECTIVE WT.
LEVEL ONE	WT #1	LEVEL TWO	WT #2	LEVEL THREE	WT #3	#1 X #2 X #3
UTILITIES		Connect/Disconnect		17. Time/labor required 18. Safety 19. Spill protection	1.00	
		20. Efficiency of supply location/cable hose runs 21. Accessibility/ease of maintenance 22. Protection from damage 23. Expansion potential	1.00			
CONSTRUCTION		24. Compatible with current methods				
		Time	1.00	25. Total construction time 26. On-site time	1.00	
UNIQUE DESIGN FEATURES	1.00					1.000

Figure D-1. Factor Weighting Form (Continued)

5.0 RATING THE DESIGNS

To rate the designs, follow these steps:

a. Become familar with the list of evaluation factors in table D-1.

b. Read the measurement and scoring methodology in paragraph 6.0.

c. Review the pier designs to be evaluated. If two (or more) designs are being compared, they should be reviewed together.

d. Using the pier design documentation and paragraph 6.0, perform the analysis, estimation, or measurement calculations for each scored factor. Figure D-2 provides a form for recording the results of this work. If you cannot measure or evaluate a factor with a degree of confidence, leave the score blank, but weight the factor if it is important to the evaluation.

e. Use figure D-1 to weight the evaluation factors. Multiply the weights you assign across the columns to obtain the effective weight for each scored factor. Enter these in the "EFF. WEIGHT" column on figure D-2, The same weights must, of necessity, be used for each design being evaluated. If you believe a factor is not important to the pier design, assign a weight of 0 and do not score it. Make sure, however, that your weights for the other factors in that group total to 1.0

f. On figure D-2, multiply each score by its effective weight to obtain the rating. The total of the "RATING" column is the numerical rating for the design.

g. The numerical scores and rating of one design are not too important by themselves, but the relationship of the scores for alternative designs being compared is important. After completing the rating sheets for each design, compare the scores to see if they reflect the way you see that factor. In other words, make sure the scores assigned are in line with your evaluation.

6.0 MEASUREMENT AND SCORING CRITERIA

Criteria for measuring and scoring the 26 evaluation factors follow:

1. <u>Capacity, ships at berth</u>.

Measure: One AD plus the number of ships at berths when balance of available berthing space is divided between the average space required for CG/DD types and FF/FFG types. Spacing to be in accordance with Design Manual (DM)25.1.

Example: 1200' (one side of pier) - 643' for AD - 100' spacing between ships = 457' remaining.
Average space required for one CG/CGN/DD = 570'.
Average space required for one FF/FFG = 440'.
Space on AD side for 1 FF.
1200' on other side of pier = 1 CG + 1 FF.
Therefore, the pier will berth 1 AD + 1 CG + 2 FF

Scoring: The design accommodating the highest number of ships = 10. Other alternatives scored as a decimal of the highest number; i.e., if 5 ships is the highest = 10, then 4 ships = 8. An alternate scoring method is to establish an expected optimum number of ships for the particular site and use that number as the norm, or par. Then, establish a minimum number of ships acceptable for the site. Scoring for the designs would be based on these two points, with the norm scoring 8 and the minimum scoring 2. A design berthing more than the norm would score above 8 and one berthing less than the minimum would score 0.

2. Nesting capacity.

Measure: Total number of ships that may be berthed, in addition to those in factor 1, when calculated in accordance with Design Manual-25.1.

Scoring: Same as factor 1.

3. Utilization of water area.

Measure: $\dfrac{\text{Water area occupied by pier}}{\text{Total water area available for pier/ships}}$

Scoring: Lowest percentage = 10
Other alternative designs scored relative to the lowest.

4. Utilization of land area.

Measure: $\dfrac{\text{Land area or length of shoreline required by design}}{\text{Total available for project}}$

Scoring: Same as factor 3.

5. Restraint system compatibility with ship line patterns.

Measure: Overlay line patterns for ship types to be berthed on pier design restraint system. Visually judge the compatibility.

Scoring: Score design between 0 and 10 based on judgment.

6. Tie-up line/tending time.

Measure: Estimated time in minutes required to tie ship under normal conditions using standard procedure. Estimated average time in minutes per day required by CG/DD/FF type ships for recurring line tending based on the design evaluated.

Scoring:

Minutes	Points
over 18	0
18	2
16	4
14	6
12	8
10	10

7. Effectiveness of fendering.

Measure: Analyze the ability of the design to protect the ships concerned as a first priority, and to protect the pier as a second priority. Consider physical characteristics of ships; e.g., hull strength, masker bands, sonar domes, etc.

Scoring: Score between 0 and 10 based upon the analysis.

8. Fender system life expectancy.

Measure: Estimated time in years before fenders would require a major repair/replacement assuming normal maintenance and repair of periodic damage are accomplished.

Scoring:

Years	Points
less than 5	0
6	2
8	6
10 or more	10

9. Ease of fender system repair.

Measure: Judgment based on an analysis of the difficulty of procuring and replacing component parts of the system, the extent and complexity of equipment required, accessibility of the system, feasibility of repair within current activity capabilities, etc.

Scoring: Between 0 and 10 based on the analysis.

10. Elimination of camels.

Measure: Does the design eliminate the need for floating camels between the pier and the ship?

Scoring: Yes = 10 No = 0

11. Clear deck space.

Measure: Area of deck or decks in square yards (yd^2)that is clear of obstructions and available for vehicle/personnel traffic and as a working platform for ship requirements, maintenance activities, etc. If solid waste containers are required on the main deck, deduct the area required.

Scoring: 8,000 yd^2 = 0 (60' x 1200')
10,000 yd^2 = 5 (75' x 1200')
13,300 yd^2 = 10 (100' x 1200')

Score designs above 10,000 yd^2 based on a percentage of 13,300; e.g., 12,000 yd^2 = 9, 11,000 = 8. Score designs between 10,000 yd^2 and 8,000 yd^2 between 0 and 5.

12. Pier top deck elevation relative to mean low water (MLW).

Measure: Distance in feet from the top deck to MLW.

Scoring:

Feet	Points
14	0
15	2
16	4
17	6
18	8
19	9
20	10
21	9
22	6
23	3
24	0

13. Pier top deck elevation relative to mean high water (MHW).

Measure: Distance in feet from the top deck to MHW.

Scoring:

Feet	Points
over 20	0
20	10
19	9
18	7
17	6
16	5
15	4
14	0

14. Tug assistance.

Measure: Does the pier design force the use of tugs to berth CG/DD/FF type ships under calm water, good weather conditions? Do not consider natural conditions that may dictate use of tugs, but only the pier design.

Scoring: No = 10
Yes = 0

15. <u>Safety of approach</u>.

Measure: This factor requires a qualitative judgment based on the pier configuration, water/approach area and distances allowed, angle of approach, etc.

Scoring: 0 to 10 based on judgment.

16. <u>Heavy lift/load/unload efficiency</u>.

Measure: Analyze the design as it relates to providing crane service for heavy lifts and loading the ship with necessary food, stores, cargo, and personal gear. Factors to be considered include deck elevation and crane service space, space available for staging areas, efficiency of using portable/self-powered conveyors, etc.

Scoring: 0 to 10 based on analysis.

17. <u>Utilities connection time/labor</u>.

Measure: Estimate the number of people and time required to connect all utilities to a DD-963 class ship upon arrival.

Scoring:

Man-Hours	Points
over 80	0
70	2
60	4
50	6
40	8
30 or less	10

18. <u>Utilities safety</u>.

Measure: A judgment of the safety factor of electrical and steam connections and service related to pier design.

Scoring: Assign a grade of 0 to 10.

19. <u>Utilities spill protection</u>.

Measure: With the design being evaluated, what happens in the event of an accidental disconnect of a fuel, sewage, or oily waste line at the pier service point? Are there features that mitigate the resulting spill or would the spill cause problems with other utilities, access areas, traffic patterns, etc.?

Scoring: 0 to 10 grade.

20. Efficiency of utility supply locations, cable/hose runs.

Measure: Analyze the design based on:

- Location of utility connect points along the length of the pier related to the location of ship connections. How long do the cables/hoses have to be to reach the inboard ship?
- Vertical distance between supply points and the ship connection level.
- Practicality of utilizing mechanical aids to place cables/hoses aboard the ship.
- Efficiency of placing cable/hoses when only manpower is available.

Scoring: A grade of 0 to 10 based on judgement compared with current experience.

21. Access/ease of utility system maintenance.

Measure: Analyze the design of utility systems on the pier from the standpoint of accessibility for maintenance, repair, and replacement of components. Can transformers be removed and replaced, pumps and valves maintained, sections of lines replaced, etc. without shutting down the pier or a berth?

Scoring: 0 to 10 based on analysis.

22. Protection of utilities from damage.

Measure: Does the design adequately protect the utility distribution systems and supply points from vehicle traffic, cranes, etc?

Scoring: Assign a grade of 0 to 10.

23. Utility expansion potential.

Measure: Does the design provide efficient space for expansion of utilities, including room for additional power vaults?

Scoring: A grade of 0 to 10 based on the degree of expansion potential without structural changes in the pier.

24. Construction compatible with current method.

Measure: A qualitative measure based on an analysis of the construction required to build the design. Are unique methods required, or can the pier be constructed by methods generally is use in the construction industry?

Scoring: 0 to 10 based on the analysis. A high score is assigned to the design requiring no unique methods. The score is decreased based upon the degree of unusual construction involved.

25. Total construction time.

Measure: Estimated time in months required to construct the pier.

Scoring:

Months	Points
24	2
22	4
20	6
18	8
16	10

26. Onsite construction time.

Measure: Estimated time in months required for construction at the pier site.

Scoring:

Months	Points
24	0
20	4
16	6
12	8
8	10

PIER DESIGN EVALUATION WORKSHEET

PIER DESIGN: ______________________

Page 1

SCORED FACTOR	UNIT OF MEASURE	ACCEPTABLE MEASURE/SCORE			MEASURE	SCORE	EFF. WEIGHT	RATING
		MINIMUM	NORM	MAXIMUM				
1. Ships at berth	No. of ships							
2. Nesting capacity	No. of ships							
3. Water area	% of available							
4. Land area	% of available							
5. Comp. w/line patterns	analysis							
6. Tie-up/line tending time	minutes							
7. Fender effectiveness	analysis							
8. Life expectancy	years							
9. Ease of repair	analysis							
10. Eliminate camels	Yes-No							
11. Clear deck space	square yards							
12. Deck elevation/MLW	feet							
13. Deck elevation/MHW	feet							
14. Tug assistance	Yes-No							

Figure D-2. Evaluation Worksheet

PIER DESIGN EVALUATION WORKSHEET

PIER DESIGN: ______________________

SCORED FACTOR	UNIT OF MEASURE	ACCEPTABLE MEASURE/SCORE			MEASURE	SCORE	EFF. WEIGHT	RATING
		MINIMUM	NORM	MAXIMUM				
15. Safety of approach	analysis							
16. Heavy lift/load service	analysis							
17. Utilities connect time/labor	man-hours							
18. Utility safety	analysis							
19. Spill protection	analysis							
20. Eff. of utility supply	analysis							
21. Ease of maintenance	analysis							
22. Protection of utilities	analysis							
23. Expansion potential	analysis							
24. Constr. methods	analysis							
25. Constr. time-total	months							
26. On-site time	months							

Figure D-2. Evaluation Worksheet (Continued)

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